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COMPUTER AIDED DATA ACQUISITION AND ANALYSIS FOR A MERCURY POROSIMETER

I.S. Parsons, R.J. Mikula and V.A. Munoz

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COMPUTER AIDED DATA ACQUISITION AND ANALYSIS FOR A MERCURY POROSIMETER

by

I. S. Parsons*, R. J. Mikula** and V. A. Munoz***

ABSTRACT

Software has been developed for a desk top computer to acquire and analyze data obtained from a Micromeritics Model 9300 mercury pore sizer. This report describes the software and the current progress in automating data acquisition. The software is written using BASIC on the Hewlett Packard 9826A and 9845B desk top computers. The data acquisition unit is a Hewlett Packard 3054 data logger. The hardware link required for the data acquisition simply involves overriding the manual pressure control with one controlled from the computer. Outputs of the pressure and intrusion measurements are already provided. The computer control of the experiment only applies to the high pressure cell, allowing for simultaneous manual operation of the low pressure cells.

The purpose of this report is to document the wiring and programming steps required to automate the Micromeritics 9300 using a Hewlett Packard 3054 data logger and 9826A (or 9845B) computer. The automation includes operation of the high pressure cell for data acquisition and complete data processing options similar to those suggested in the Micromeritics operators manual.

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ACQUISITION ET ANALYSE DE DONNÉES ASSISTÉES PAR ORDINATEUR D'UN POROSIMÈTRE AU MERCURE

Un logiciel d'ordinateur de table a été élaboré pour analyser des données recueillies par un porosimètre au mercure (Micromeritics Model 9300). Le présent rapport décrit le logiciel et les progrès accomplis en matière d'acquisition automatique des données. Le logiciel est rédigé en BASIC sur des ordinateurs de table Hewlett Packard 9826A et 9845B. L'unité d'acquisition des données est un consignateur de données Hewlett Packard 3054. La liaison machine nécessaire à l'acquisition des données consiste simplement à remplacer la commande de pression manuelle par une commande informatisée. Des sorties de données de mesure de la pression et de l'intrusion sont déjà fournies. La commande par ordinateur de l'expérience ne s'applique qu'à la cellule haute pression, permettant une exploitation manuelle simultanée des cellules basse pression.

Le présent rapport a pour objet de documenter les étapes de connexion et de programmation nécessaires à l'optimisation du Micromeritics 9300 relié à un consignateur de données Hewlett Packard 3054 et un ordinateur 9826A (ou 9845B). L'automatisation s'applique notamment à l'exploitation de la cellule haute pression pour l'acquisition des données et leur traitement complet tel que proposé dans le manuel de l'usager de Micromeritics.

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INTRODUCTION

The data normally collected on the Micromeritics 9300 porosimeter includes low pressure intrusion readings (10 kPa to atmosphere), after which the penetrometer is removed to the high pressure cell. After the preparation is complete the pressure is increased from one atmosphere to 200 MPa in a regular fashion. The intrusion reading is alloved to stabilize and the data is recorded before proceeding to the next higher pressure. At 200 MPa, the highest pressure, the direction is reversed and the extrusion data is collected for the same series of pressures used to acquire the intrusion data. After the data has been collected it is necessary to convert it into a form which would be more easily understood. Several programs were developed for the desk top computer to ease this bottleneck in the analysis. Computer acquisition of the data in conjunction with the data analysis allows for greatly increased productivity.

The first step in automating the data acquisition was to allow the computer to acquire the high pressure data unattended. This was accomplished by paralleling the up and down pressure switch using two high voltage activators and using the data logger's digital voltmeter to monitor the high pressure and intrusion readings. These last two are in the range 0-5 volts DC. The pressure and intrusion outputs are already available in the 9 pin connector at the back of the porosimeter. See Figure 1 for a schematic of the wiring.

The computer can control the high pressure up or down depending on the pressure set point desired. The intrusion is read periodically (on a time base set by the user) and after 3 periods with the same intrusion the pressure and intrusion data is recorded and the next pressure set point is selected. This ensures that the intrusion of mercury into the sample has equilibrated and that an accurate intrusion value is measured at each pressure. When all the data points, both increasing and decreasing in pressure, are recorded, the porosimeter is returned to the starting point and is ready for the next sample or cycle. While the automatic high pressure data acquisition is proceeding the low pressure samples can be set up or low pressure data can be collected by the operator, increasing the rate at which smaples can be processed.

DATA ANALYSIS

The user decides to use either a data file or input data manually. The information input either way is as follows:

1) The date the test was performed.
2) The title of the data set (up to 50 characters).
3) The penetrometer identifier (up to 10 characters).
4) The penetrometer stem diameter (cm).
5) The penetrometer volume (cm^3).
6) The penetrometer stem length (cm).
7) The stem correction factor ($cm^3\ pF^{-1}$).
8) The contact angle (degrees).
9) The surface tension of mercury (dynes cm^{-1}).
10) The temperature the test was performed at (°C).
11) The number of low pressure points.
12) The highest pressure point.
13) The total number of pressure points.
14) The low pressure intrusion data (Pressure (MPa), intrusion (pF)).
15) The cycle number.
16) The high pressure intrusion data.
17) The high pressure extrusion data.

Figure 2 shows a flow diagram of the computing logic, with the complete program listing for the HP9826A microcomputer in Appendix A. The tables produced will contain all the data used in the various plots (Tables 1 and 1a). There are two options for hard copy of the plots seen on the screen. They are either a thermal printer copy off the screen or a plotter copy. Figures 3 to 6 show examples of the thermal printer output, and Figures 3a to 6a show the corresponding plotter output. Appendix B gives a brief outline of the theory behind the mercury porosimeter data analysis and the source of the following plots.

The first plot, (Figure 3) is the pressure applied vs pore volume. The cut off pressure will enable the user to calculate the corrected area from the linear region of the graph. The cut off pressure is simply an empirical

pressure defined as the pressure above which the increase in pore area is linear. The linear rise in pore area is sometimes only due to sample compressibility and therefore, rather than use the total pore area or volume as a sample characteristic, one uses the corrected area (volume) which is simply the pore area determined by extrapolating the linear region back to 0 MPa. The y-intercept is then the corrected area (volume).

This can be done several times to achieve the desired correlation since the data points beyond the cut off pressure are fit to a linear regression. If the first choice of a cut off pressure does not yield a satisfactory correlation, then a higher pressure can be chosen. If there is no linear rise in the pore area (volume) then it is likely that in this sample, pore structure is the more significant factor rather than the sample compressibility. Two important items to keep in mind are that:

1) it takes at least two points to do the calculation
2) the volume at 0 MPa pressure must lie between the smallest and largest volumes otherwise the area will not be calculated.

The user can get a hard copy on the printer or plotter if desired.

The second plot (Figure 4) is a plot of the pore diameter (μm) (on a logarithmic scale) vs. per cent pore volume. The value for the one hundred per cent of scale is printed out on both the thermal printer and plotter hard copies. The third plot (Figure 5) is a plot of the logarithm of mean pore diameter (μm) vs per cent delta pore volume. The value for the one hundred per cent of scale is printed out on both the thermal printer and plotter hard copies.

The fourth plot (Figure 6) is a plot of the logarithm of mean pore volume (μm) vs per cent pore area. The value for the one hundred per cent of scale is printed out on both the thermal printer and plotter outputs.

SUMMARY

Although the complete program is reproduced here, anyone wishing to implement a similar automation could contact our laboratory for the source code on either disk or tape. This would eliminate time consuming errors and subsequent de-bugging. As can be seen by careful reading of the source

code, our equilibration interval is 30 seconds. Since any reading requires three consecutive identical intrusion readings per pressure, this allows ample time for sample equilibration. This time and the number and value of the pressure readings are at the experimenters discretion.

For cycle 1 20 Feb 1984
BC COAL 1688 0T 2W/100 C/10 ml N2/min 28x60 mesh

Sample Mass	3.0000 g	Penetrometer Number	04-0486
Penetrometer Volume	15.4569 cc	Stem Conversion Factor	21.63E-03 cc/pF
Penetrometer Stem Diameter	0.25 cm	Penetrometer Length	23 cm
Mercury Surface Tension	485 dynes/cm	Contact Angle	130.0 degrees

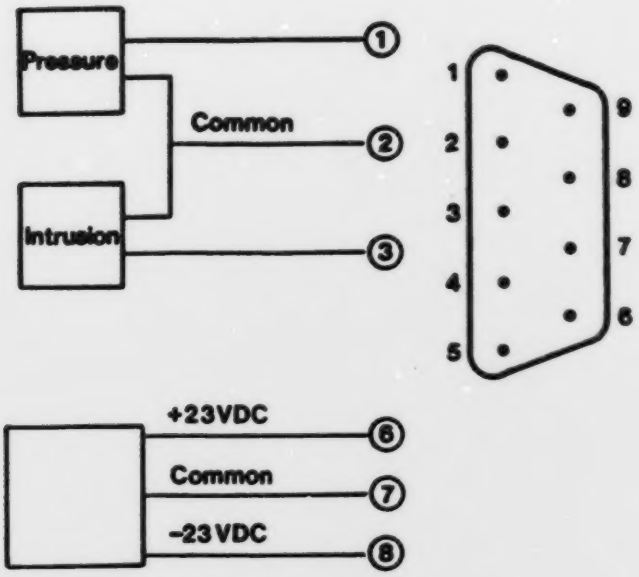
Data Points= 36 Highest Pressure Reading= 22 Low Pressure Reading= 7
Temperature = 24.6 °C Mercury density = 13.5350 g/cc

Pressure Reading (MPa)	Corrected Pressure (MPa)	Pore Size Diameter (μm)	Intrusion Reading (pF)	Cumulative Intrusion (pF)	Cumulative Pore Volume (cc)	Pore Volume (cc/g)
LOW PRESSURE INTRUSION DATA						
.029	.029	24.571	60.48	0.00	0.000	0.000
.040	.040	17.814	58.90	1.58	0.034	0.011
.050	.050	14.251	57.99	2.49	0.054	0.018
.060	.060	11.876	57.38	3.10	0.067	0.022
.070	.070	10.179	56.92	3.56	0.077	0.026
.080	.080	8.907	56.59	3.89	0.084	0.028
.090	.090	7.917	56.33	4.15	0.090	0.030
HIGH PRESSURE INTRUSION DATA						
.110	.138	5.160	58.72	0.00	0.090	0.030
1.000	1.027	.694	56.18	2.54	0.145	0.048
2.030	2.056	.347	55.32	3.40	0.163	0.054
5.020	5.046	.141	54.29	4.43	0.186	0.062
10.010	10.035	.071	53.68	5.04	0.199	0.066
20.000	20.025	.036	53.21	5.51	0.209	0.070
30.030	30.055	.024	52.94	5.78	0.215	0.072
40.030	40.055	.018	52.70	6.02	0.220	0.073
50.030	50.054	.014	52.51	6.21	0.224	0.075
75.060	75.084	.009	52.01	6.71	0.235	0.078
100.030	100.054	.007	51.64	7.08	0.243	0.081
125.100	125.124	.006	51.29	7.43	0.250	0.083
150.030	150.054	.005	50.93	7.79	0.258	0.086
175.080	175.103	.004	50.54	8.18	0.267	0.089
200.030	200.053	.004	50.22	8.50	0.274	0.091
HIGH PRESSURE EXTRUSION DATA						
174.920	174.943	.004	50.48	8.24	0.268	0.089
150.000	150.023	.005	50.76	7.96	0.262	0.087
124.870	124.894	.006	51.09	7.63	0.255	0.085
99.990	100.014	.007	51.52	7.20	0.246	0.082
74.990	75.014	.009	51.97	6.75	0.236	0.079
49.970	49.994	.014	52.43	6.29	0.226	0.075
39.930	39.955	.018	52.66	6.06	0.221	0.074
29.980	30.005	.024	52.88	5.84	0.216	0.072
19.940	19.965	.036	53.15	5.57	0.210	0.070
9.970	9.995	.071	53.37	5.35	0.205	0.068
4.990	5.015	.142	53.63	5.09	0.200	0.067
2.000	2.025	.352	54.00	4.72	0.192	0.064
.980	1.006	.709	54.41	4.31	0.183	0.061
.080	.107	6.672	56.48	2.24	0.138	0.046

Table 1. Listing of data output showing pressure reading and all data for the subsequent plots.

P (MPa)	V (cc/g)	$\bar{D}$ (μm)	$\bar{F}$ (MPa)	dV (cc/g)	$\bar{F}$dV	$\Sigma\bar{F}$dV	Cumulative Area (m^2/g)	per cent
LOW PRESSURE INTRUSION DATA								
.029								
.040	0.011	21.192	.035	0.011	3.93E-04	3.93E-04	1.28E-03	.017
.050	0.018	16.032	.045	0.007	2.95E-04	6.88E-04	2.25E-03	.030
.060	0.022	13.063	.055	0.004	2.42E-04	9.30E-04	3.04E-03	.041
.070	0.026	11.027	.065	0.003	2.16E-04	1.15E-03	3.74E-03	.050
.080	0.028	9.543	.075	0.002	1.78E-04	1.32E-03	4.32E-03	.058
.090	0.030	8.412	.085	0.002	1.59E-04	1.48E-03	4.84E-03	.065
HIGH PRESSURE INTRUSION DATA								
.110	0.030	6.538	.114	0.000	0.00E+00	1.48E-03	4.84E-03	.065
1.000	0.048	2.927	.582	0.018	1.07E-02	1.21E-02	3.96E-02	.530
2.030	0.054	.520	1.541	0.006	9.56E-03	2.17E-02	7.08E-02	.946
5.020	0.062	.244	3.551	0.007	2.64E-02	4.81E-02	1.57E-01	2.096
10.010	0.066	.106	7.540	0.004	3.32E-02	8.12E-02	2.65E-01	3.542
20.000	0.070	.053	15.030	0.003	5.09E-02	1.32E-01	4.31E-01	5.762
30.030	0.072	.030	25.040	0.002	4.87E-02	1.81E-01	5.90E-01	7.888
40.030	0.073	.021	35.055	0.002	6.07E-02	2.42E-01	7.88E-01	10.532
50.030	0.075	.016	45.055	0.001	6.17E-02	3.03E-01	9.90E-01	13.223
75.060	0.078	.012	62.569	0.004	2.26E-01	5.29E-01	1.73E+00	23.058
100.030	0.081	.008	87.569	0.003	2.34E-01	7.62E-01	2.49E+00	33.243
125.100	0.083	.006	112.589	0.003	2.84E-01	1.05E+00	3.42E+00	45.630
150.030	0.086	.005	137.589	0.003	3.57E-01	1.40E+00	4.58E+00	61.200
175.080	0.089	.004	162.578	0.003	4.57E-01	1.86E+00	6.07E+00	81.131
200.030	0.091	.004	187.578	0.002	4.33E-01	2.29E+00	7.48E+00	100.000
HIGH PRESSURE EXTRUSION DATA								
174.920	0.089	.004	187.498	-0.002	-3.51E-01	1.94E+00	6.34E+00	84.676
150.000	0.087	.004	162.483	-0.002	-3.28E-01	1.61E+00	5.27E+00	70.374
124.870	0.085	.005	137.459	-0.002	-3.27E-01	1.29E+00	4.20E+00	56.115
99.990	0.082	.006	112.454	-0.003	-3.49E-01	9.38E-01	3.06E+00	40.915
74.990	0.079	.008	87.514	-0.003	-2.84E-01	6.55E-01	2.14E+00	28.535
49.970	0.075	.012	62.504	-0.003	-2.07E-01	4.47E-01	1.46E+00	19.497
39.930	0.074	.016	44.974	-0.002	-7.46E-02	3.73E-01	1.22E+00	16.246
29.980	0.072	.021	34.980	-0.002	-5.55E-02	3.17E-01	1.03E+00	13.827
19.940	0.070	.030	24.985	-0.002	-4.86E-02	2.68E-01	8.76E-01	11.706
9.970	0.068	.053	14.980	-0.002	-2.38E-02	2.45E-01	7.99E-01	10.670
4.990	0.067	.107	7.505	-0.002	-1.41E-02	2.31E-01	7.53E-01	10.057
2.000	0.064	.247	3.520	-0.003	-9.39E-03	2.21E-01	7.22E-01	9.647
.980	0.061	.530	1.515	-0.003	-4.48E-03	2.17E-01	7.07E-01	9.452
.080	0.046	3.690	.556	-0.015	-8.30E-03	2.08E-01	6.80E-01	9.090

Table 1. (continued)



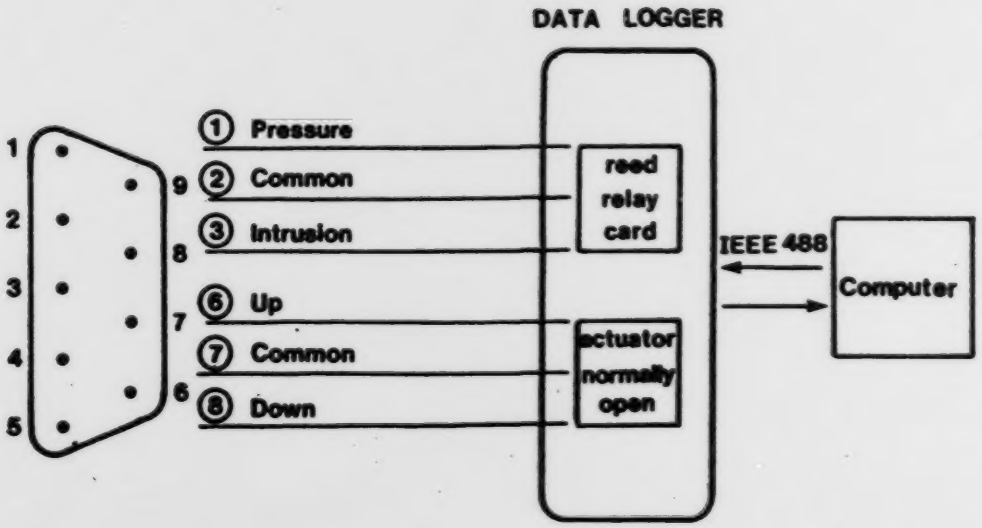


Figure 1. Schematic diagram of the wiring at the 9 pin connector on the porosimeter.

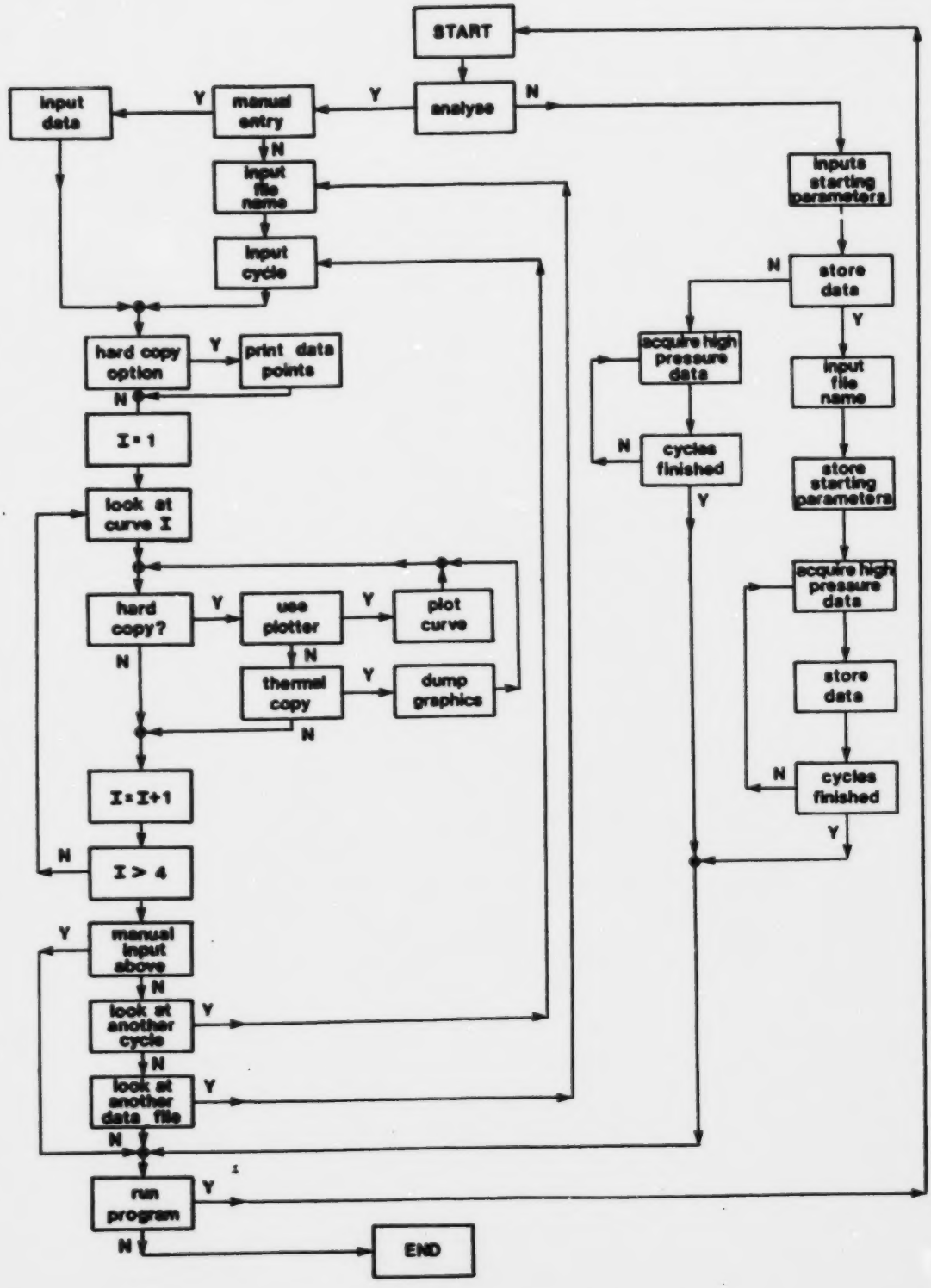


Figure 2. A flow diagram of the computing logic.

Equation for the line is: Volume = 0.0706 + 1.035E-04 * Pressure
r^2 is 0.999
Number of points used were 5
The cut off pressure was 90.0 MPa

Corrected area is 5.083E-01 m^2/g

Pressure (MPa) vs Pore Volume (cc/g)

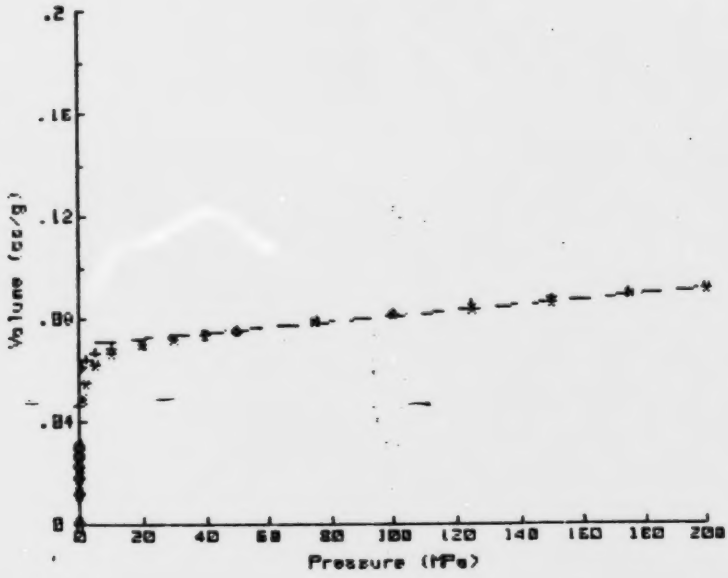


Figure 3. Pressure applied vs. pore volume. The cut off pressure extrapolation is seen as the dashed line (thermal printer).

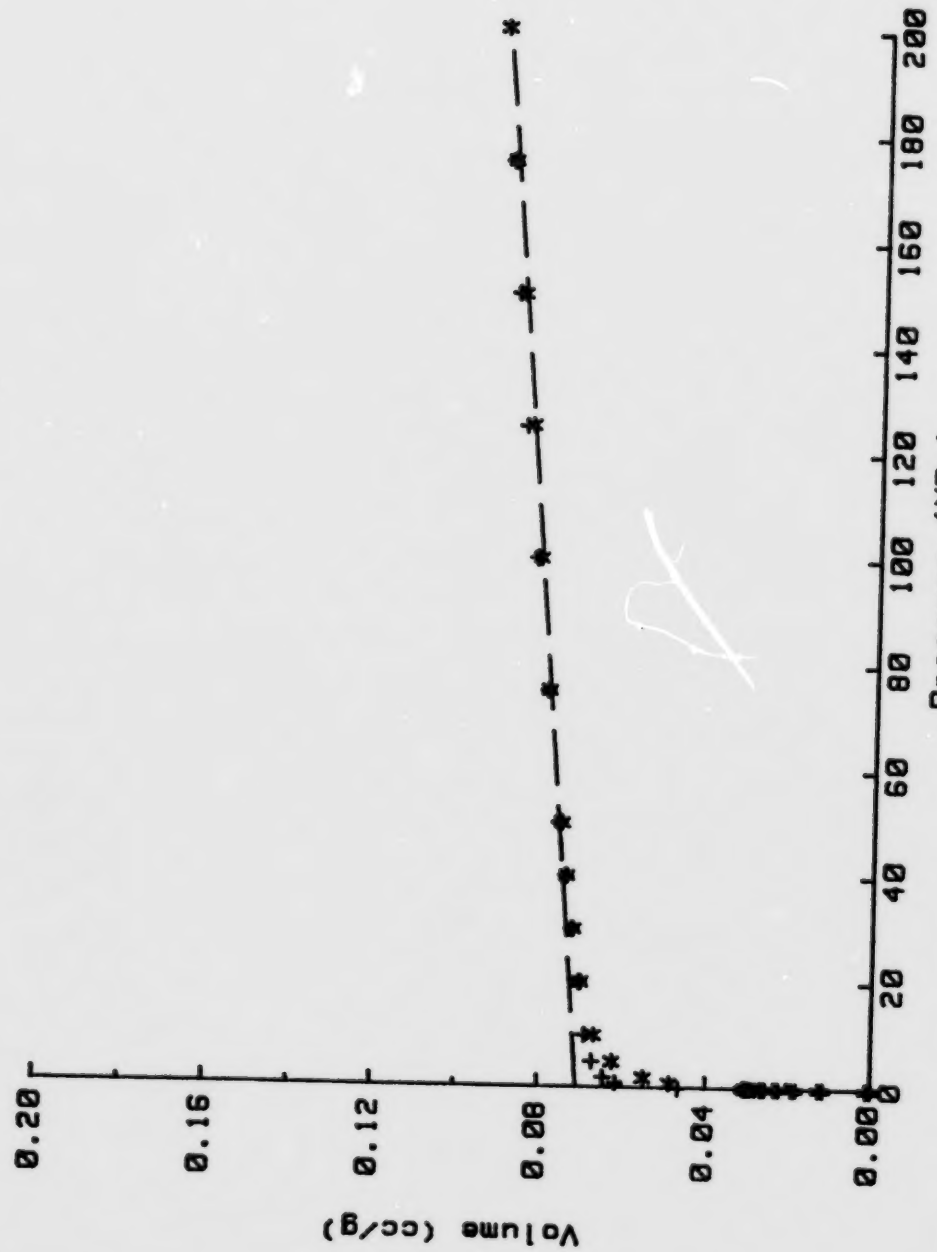


Figure 3a. Pressure applied vs. pore volume. The cut off pressure extrapolation is seen as the dashed line (plotter output).

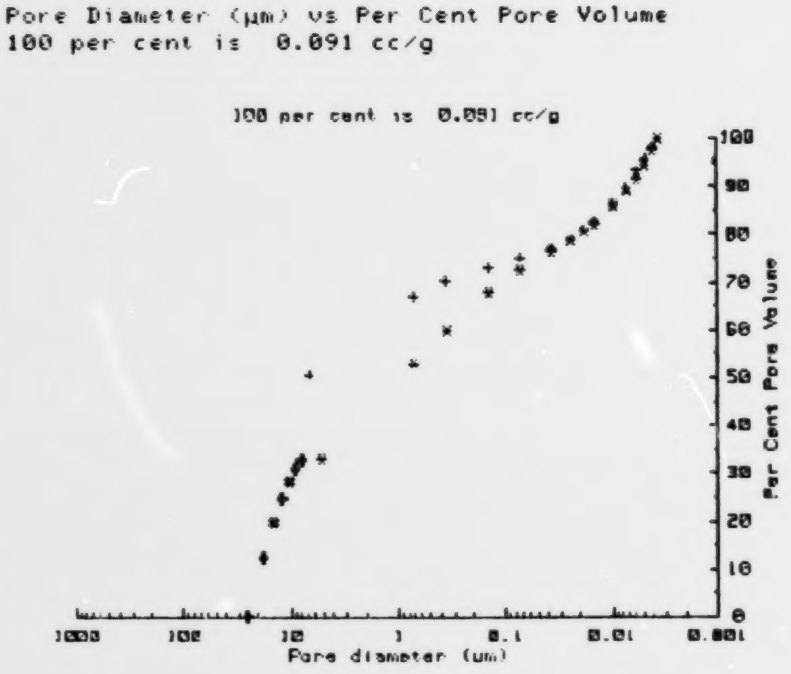


Figure 4. Pore diameter (on a logarithmic scale) vs. per cent pore volume (thermal printer

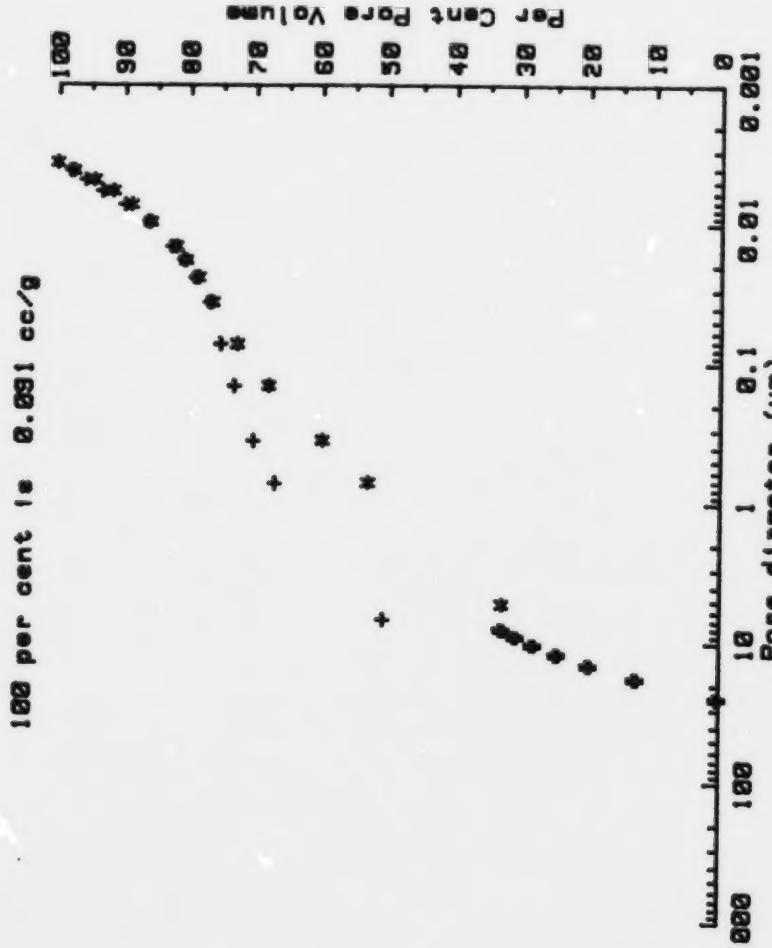


Figure 4a. Pore diameter (on a logarithmic scale) vs. per cent pore volume (plotter output).

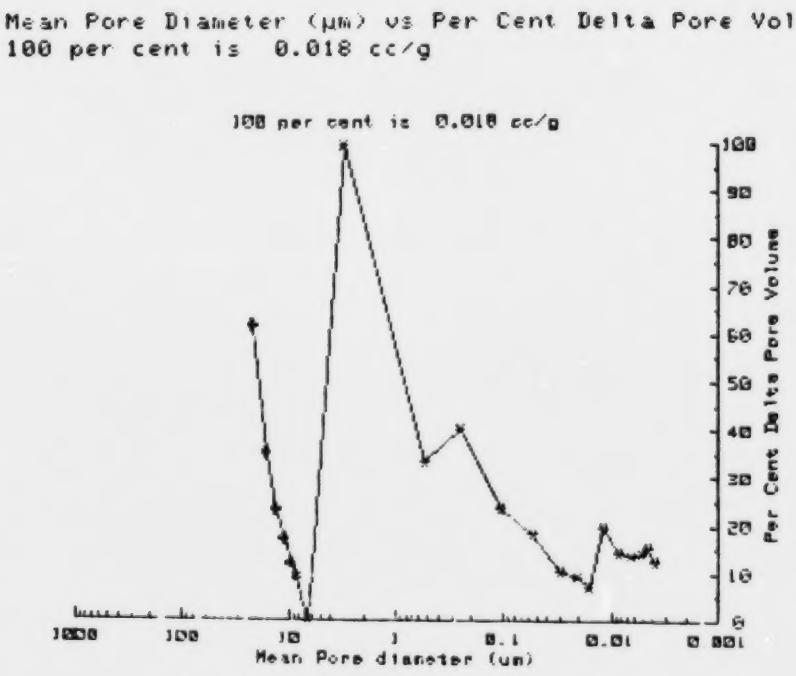


Figure 5. Mean pore diameter (on a logarithmic scale) vs. per cent delta pore volume (thermal printer).

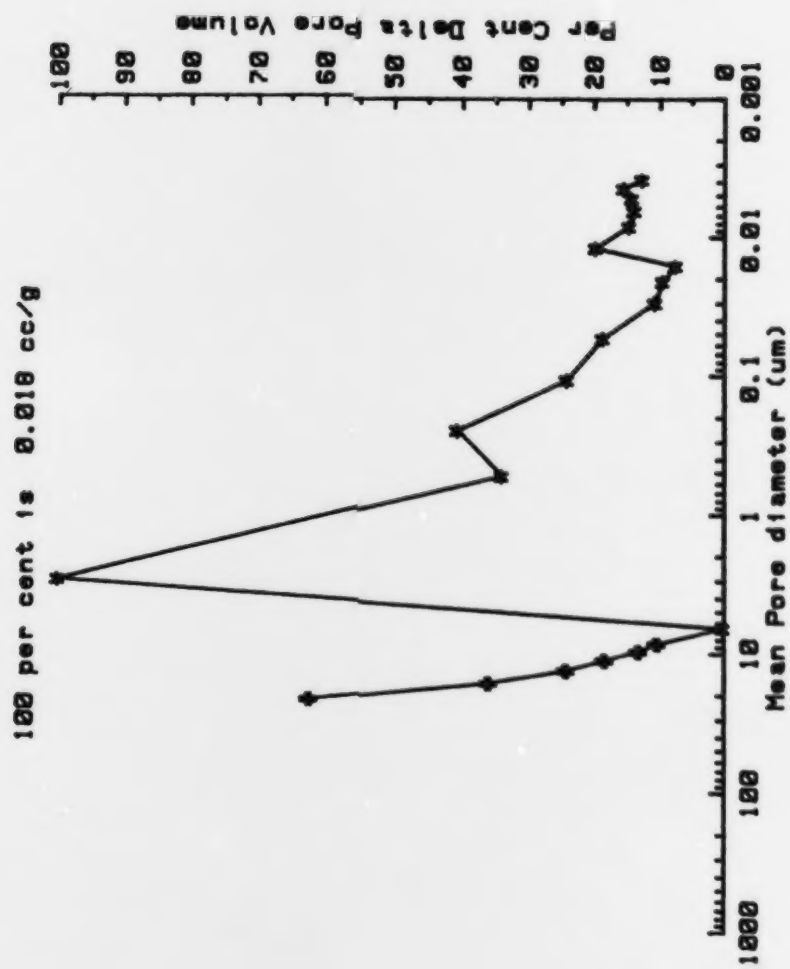


Figure 5a. Mean pore diameter (on a logarithmic scale) vs. per cent delta pore volume (plotter output).

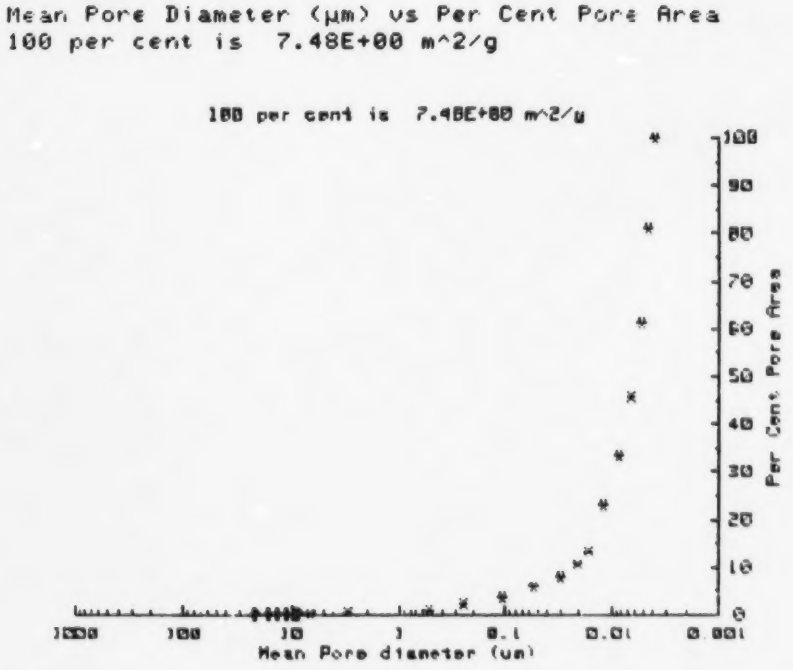


Figure 6. Mean pore diameter (on a logarithmic scale) vs. per cent pore area (thermal printer).

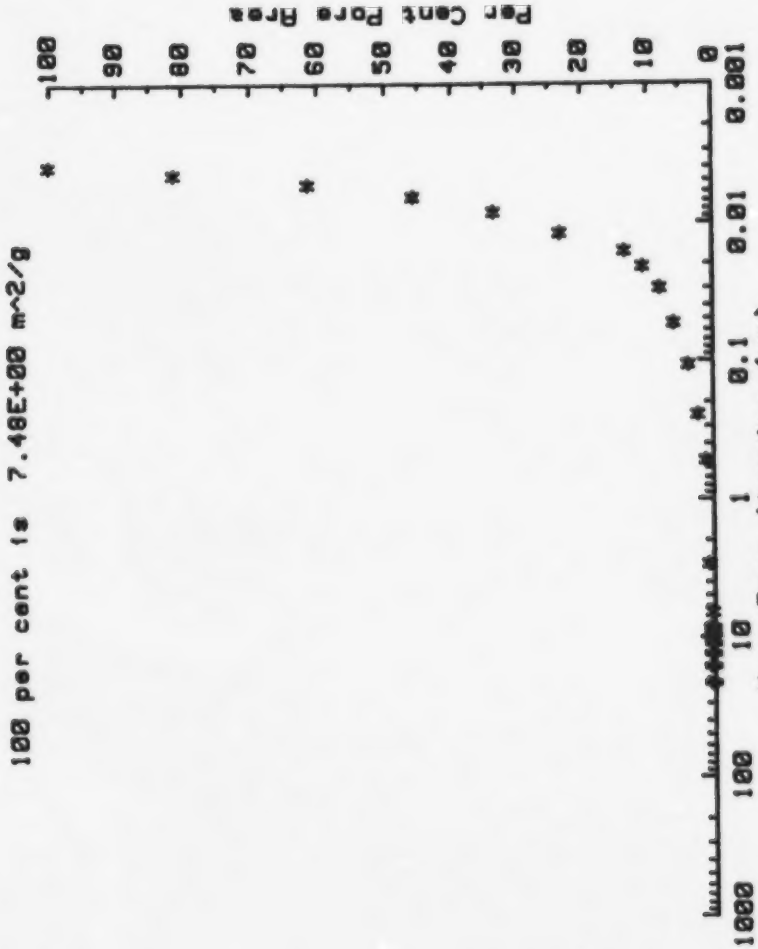


Figure 6a. Mean pore diameter (on a logarithmic scale) vs. per cent pore area (plotter output).

APPENDIX A: Source code for the mercury porosimeter automation and data analysis.

```
5     REM ****************************************
10    REM *                                      *
15    REM *   COAL RESEARCH LABORATORY EDMONTON  *
20    REM *                                      *
25    REM * Data acquisition and analysis program*
30    REM * for Model 9300 Mercury Poresimeter   *
35    REM * manufactured by Micrometerics        *
40    REM *                                      *
45    REM * The data analysis system is made by  *
50    REM * Hewlett-Packard and is as follows    *
55    REM *                                      *
60    REM * Computer   - HP9826A                 *
65    REM * Printer    - HP9876A                 *
70    REM * Plotter    - HP9872C                 *
75    REM * Datalogger - HP3054                  *
80    REM *               44421 relay card       *
85    REM *               44428 actuator card    *
90    REM *  written by I.S. Parsons  March 1984 *
95    REM *  last modification        June  1984 *
100   REM ****************************************
105   REM
110   REM ***************************
115   REM Common block declarations
120   REM ***************************
125   REM
130   REM *************
135   REM /Poresimeter/ -> For data acquisition
140   REM *************
145   REM
150   REM Slot    The number of the slot in the
155   REM         datalogger for actuator card
160   REM Up      Number of relay on actuator card
165   REM         to control increasing pressure
170   REM Down    Number of relay on acutator card
175   REM         to control decreasing pressure
180   REM Pressure The relay number to monitor the
185   REM          high pressure sensor (0-5V)
190   REM Intrusion Relay number to monitor the
195   REM           high pressure intrusion sensor
200   REM           (0-5V)
205   REM @Poresimeter  I/O path name for the
210   REM               computer - poresimter link
215   REM
220   REM ******
225   REM /Read/ -> Cyclical monitoring of high
230   REM ******    pressure and intrusion values
235   REM
240   REM Mpa       The current high pressure value
245   REM           in MPa
250   REM Pf        The current high pressure
255   REM           intrusion value in pF
260   REM Timeit    Counter increment the number of
265   REM           readings taken since last
270   REM           comparision
271   REM Reader    The time between readings of
272   REM           of the datalogger (seconds)
275   REM
280   REM ************
285   REM /Constants/ ->Output device select codes
290   REM ************   and plotter definitions
295   REM                as well as mass storage
300   REM                device and security codes
305   REM
310   REM Hcopy  Select code for hard copy printer
315   REM Scopy  Select code for soft copy printer
320   REM        can change if using another CRT
325   REM Splot  Select code for softcopy graphics
330   REM Hplot  Select code for hard copy plotter
335   REM Datalogger  Select code for datalogger
340   REM Splot$[8]   Alpha value for softcopy
345   REM             graphics device
350   REM Hplot$[4]   Alpha value for hardcopy
355   REM             plotter
360   REM Store$[25]  Mass storage device code for
365   REM             storing or retrieving data
370   REM             files
375   REM Prog$[25]   Mass storage device code for
380   REM             retrieving program files
385   REM Security$[4] Security code for BDAT
390   REM              data files
```

```
395   REM
400   REM *********
405   REM /Analyse/ -> To analyse high and low
410   REM *********    pressure intrusion and
415   REM              high pressure extrusion
420   REM              data
425   REM Temperature   Temperature (°C) at which
430   REM               the experiment was run at
435   REM Penl          The length (cm) of the
440   REM               penetrometer
445   REM Pend          The inside diameter (cm)
450   REM               of the shaft of the
455   REM               penetrometer
460   REM Penv          The volume (cm3) of the
465   REM               penetrometer
470   REM Hgst          Mercury surface tension
475   REM               (dynes/cm)
480   REM Cona          The contact angle of the
485   REM               mercury and solid (deg)
490   REM Scf           The stem correction factor
495   REM               of the penetrometer used
500   REM D             The total number of
505   REM               readings used
510   REM Hp            The highest pressure
515   REM               reading number
520   REM Lp            The number of low pressure
525   REM               readings
530   REM Cy            The number of cycles (high
535   REM               pressure only)
540   REM Date$[25]     The date of the test
545   REM Title$[50]    The title of the test
550   REM Swt           The sample weight (g)
555   REM Pen_id$[10]   Penetrometer identifier
560   REM P(1:100)      The array containing the
565   REM               pressure data points
570   REM F(1:100)      The array containing the
575   REM               intrusion data points
580   REM Epore         The mass of the empty
585   REM               penetrometer (g)
590   REM Espore        Mass of the penetrometer
595   REM               and sample (g)
600   REM Eshgpore      Mass of the penetrometer,
605   REM               sample and mercury (g)
610   REM
615   REM ****************************************
620   REM        End of common blocks
625   REM ****************************************
630   REM
635   REM            LOCAL VARIABLES
640   REM
645   REM INTEGER
650   REM
655   REM Yes    Either set to 1 (true) or set to
660   REM        0 (false)
665   REM ****************************************
670   REM
675   COM /Poresimeter/ INTEGER Slot,Up,Down,Pressure,Intrusion,@Poresimeter
680   COM /Read/ Mpa,Pf,Timeit,Reader
685   COM /Constants/ INTEGER Hcopy,Scopy,Splot,Hplot,Datalogger
690   COM /Constants/ Splot$[8],Hplot$[4],Store$[25],Prog$[25],Security$[4]
695   COM /Analyse/ Temperature,Penl,Pend,Penv,Hgst,Cona,Scf
700   COM /Analyse/ INTEGER D,Hp,Lp,Cy
705   COM /Analyse/ Date$[25],Title$[50],Swt,Pen_id$[10],P(1:100),F(1:100)
710   COM /Analyse/ Epore,Espore,Eshgpore
715   INTEGER Yes
720   REM
725   REM ******************
730   REM Constants set here
735   REM ******************
740   REM
745   REM
750   REM ************************************
755   REM The device where the hardcopy of the
760   REM softcopy graphics is made (HP9876A)
765   REM ************************************
770   REM
775   DUMP DEVICE IS 701
780   REM
785   REM ****************************************
790   REM               Select code    device code
```

```
795   Hcopy=701     !          7              01
800   Scopy=1       !          1
805   Splot=3       !          3
810   Datalogger=709  !        7              09
815   Hplot=705     !          7              05
820   Splot$="INTERNAL"    ! Internal CRT plotter
825   Hplot$="HPGL"        ! External hard plotter
830   Store$=":INTERNAL"   ! Internal 5.25" floppy
835   Prog$=":INTERNAL"    ! Internal 5.25" floppy
840   Security$="<po>"     ! for the BDAT data file
845   REM
850   REM ***************************************
855   REM *  A chance to turn on the printer  *
860   REM ***************************************
865   REM
870   DISP "Is the printer turned on ?"
875   Pauser
880   REM ***************************************
885   REM *  A chance to turn on the plotter  *
890   REM ***************************************
895   DISP "Is the plotter turned on ?"
900   Pauser
905   REM ***************************************
910   REM *  A chance to turn on the plotter  *
915   REM ***************************************
920   DISP "Is the data logger turned on ?"
925   Pauser
930   REM
935   REM ******************************************
940   REM If you want to analyse data answer yes
945   REM otherwise answer no
950   REM ******************************************
955   REM
960 Rerun:Yes_no("Do you want to analyse data ?",Yes)
965   IF Yes THEN CALL Analyse
970   REM
975   REM ***************************************
980   REM If you want to acquire data answer yes
985   REM otherwise answer no
990   REM ***************************************
995   REM
1000  Yes_no("Do you want to collect data ?",Yes)
1005  IF Yes THEN CALL Acquire
1010  REM
1015  REM ************************************
1020  REM If you want to run the program again
1025  REM then answer yes otherwise no
1030  REM ************************************
1035  REM
1040  Yes_no("Run program again ?",Yes)
1045  IF Yes THEN Rerun
1050  END
1055  REM ******************************************
1060  REM          End of main program
1065  REM ******************************************
1070  REM
1075  SUB Initialize(W(*),@File,INTEGER Store)
1080    REM
1085    REM ***************************************
1090    REM Subprogram Initialize
1095    REM
1100    REM     Input necessary data for high
1105    REM     pressure data collection
1110    REM
1115    REM W(*)      The array containing the high
1120    REM           pressure set points
1125    REM @File     I/O path for the data to be
1130    REM           stored (Store must be set to
1135    REM           1 to be valid)
1140    REM
1145    REM INTEGER Variable
1150    REM
1155    REM Store     If 0 then data is not stored.
1160    REM           If 1 then data is stored in
1165    REM           File$
1170    REM
1175    REM The common declarations are the same
1180    REM as in the main program
1185    REM
1190    REM          LOCAL VARIABLES
```

```
1195     REM
1200     REM CHARACTER STRINGS
1205     REM
1210     REM File$[10] The name of the data file
1215     REM
1220     REM INTEGER VARIABLES
1225     REM
1230     REM Np         The number of high pressure
1235     REM            intrusion data points
1240     REM First      The initial data in blocks
1245     REM            of 256 bytes
1250     REM Filesize   The high pressure data
1255     REM            (intrusion and extrusion) in
1260     REM            blocks of 256 bytes
1265     REM Yes        Either set to 0 (false) or
1270     REM            1 (true)
1275     REM I          Counter for FOR..NEXT loops
1280     REM
1285     REM REAL VARIABLES
1290     REM
1295     REM Penhg      The mass of the penetrometer
1300     REM            just filled with mercury (g)
1305     REM Bulk_dens  The bulk density of the
1310     REM            sample
1315     REM ************************************
1320     REM
1325     COM /Constants/ INTEGER Hcopy,Scopy,Splot,Hplot,Datalogger
1330     COM /Constants/ Splot$,Hplot$,Store$,Prog$,Security$
1335     COM /Analyse/ Temperature,Penl,Pend,Penv,Hgst,Cona,Scf
1340     COM /Analyse/ INTEGER D,Hp,Lp,Cy
1345     COM /Analyse/ Date$,Title$,Swt,Pen_id$,P(*),F(*)
1350     COM /Analyse/ Epore,Espore,Eshgpore
1355     DIM File$[10]
1360     INTEGER Np,First,Filesize,Yes,I
1365     REAL Penhg,Bulk_dens
1370     REM
1375     REM ************************************
1380     REM Set the printer to the soft copy mode
1385     REM Input the starting parameters
1390     REM ************************************
1395     REM
1400     PRINTER IS Scopy
1405     REM
1410     REM ***********************************
1415     REM  Collect the current time from the
1420     REM  the time clock in the computer
1425     REM ***********************************
1430     REM
1435 Start:Date$=DATE$(TIMEDATE)
1440     REM
1445     REM ************************************
1450     REM If the timeclock is not set properly
1455     REM then output the existing date and
1460     REM let the operator modify it
1465     REM ************************************
1470     REM
1475     IF VAL(Date$[8;4])<1984 THEN
1480       OUTPUT 2;Date$;
1485       LINPUT "Correct the date",Date$
1490     END IF
1495     REM
1500     REM ***********************************
1505     REM Output the existing title and then
1510     REM allow the operator to modify and
1515     REM then input to the computer
1520     REM ***********************************
1525     REM
1530     OUTPUT 2;Title$;
1535     LINPUT "What is the title of the data ?",Title$
1540     PRINT USING "@,K,/,K";Date$,Title$
1545     REM
1550     REM************************************
1555     REM Input the temperature the mercury is
1560     REM for the experiment then calculate the
1565     REM density of mercury using it
1570     REM ************************************
1575     REM
1580     INPUT "What is the room temperature (`C) ?",Temperature
1585     PRINT "The room temperature is";Temperature;"`C"
1590     PRINT "The density of mercury is";FNHg_density(Temperature);"g/cc"
```

```
1595    REM
1600    REM ********************************
1605    REM Input the mercury surface tension
1610    REM If unknown use 485 dynes/cm
1615    REM ********************************
1620    REM
1625    INPUT "What is the mercury surface tension (dyne/cm) ?",Hgst
1630    PRINT "The mercury surface tension is";Hgst;"dynes/cm"
1635    REM
1640    REM ************************************
1645    REM Input the contact angle of the mercury
1650    REM and the solid.  If unknown use 130
1655    REM ************************************
1660    REM
1665    INPUT "What is the contact angle (degrees) ?",Cona
1670    PRINT "The contact angle is";Cona;"deg"
1675    REM
1680    REM ************************************
1685    REM Input the empty penetrometer mass and
1690    REM the mass of the penetrometer and
1695    REM sample to calculate the sample mass
1700    REM
1705    REM Input the mass of the penetrometer,
1710    REM sample and mercury to calculate the
1715    REM apparent bulk density
1720    REM ************************************
1725    REM
1730    INPUT "What is the mass of the empty penetrometer ?",Epore
1735    PRINT "The mass of the empty penetrometer";Epore;"g"
1740    INPUT "What is the mass of the penetrometer and sample ?",Espore
1745    PRINT "The mass of the penetrometer and sample";Espore;"g"
1750    INPUT "What is the mass of the penetrometer, sample & Hg ?",Eshgpore
1755    PRINT "The mass of the penetrometer, sample & Hg";Eshgpore;"g"
1760    Swt=Espore-Epore
1765    PRINT "The mass of the coal =";Swt;"g"
1770    REM
1775    REM ************************************
1780    REM Output the current penetrometer
1785    REM identifier and allow the operator to
1790    REM modify and then input to the computer
1795    REM ************************************
1800    REM
1805    OUTPUT 2;Pen_id$;
1810    LINPUT "What is the penetrometer id ?",Pen_id$
1815    PRINT "The penetrometer id = ";Pen_id$
1820    REM
1825    REM ************************************
1830    REM Input the stem correction factor to be
1835    REM used for the penetrometer during the
1840    REM experiment
1845    REM ************************************
1850    REM
1855    INPUT "What is the STEM CORRECTION FACTOR (cc/pF) ?",Scf
1860    PRINT "Stem Correction Factor";Scf;"cc/pF"
1865    REM
1870    REM ************************************
1875    REM Input the penetrometer diameter (cm)
1880    REM that is used during the experiment
1885    REM ************************************
1890    REM
1895    INPUT "What is the PENETROMETER DIAMETER (cm) ?",Pend
1900    PRINT "Penetrometer Diameter";Pend;"cm"
1905    REM
1910    REM ************************************
1915    REM The operator is allow two choices:
1920    REM
1925    REM  1) Calculate the penetrometer volume
1930    REM     by inputting the mass of the pene-
1935    REM     trometer filled with just mercury
1940    REM
1945    REM  2) Input the calculated penetrometer
1950    REM     volume
1955    REM ************************************
1960    REM
1965    Yes_no("Calculate PENETROMETER VOLUME ?",Yes)
1970    IF Yes THEN
1975      INPUT "What is the MASS OF PENETROMETER+HG ?",Penhg
1980      Penv=(Penhg-Epore)/FNHg_density(Temperature)
1985    ELSE
1990      INPUT "What is the PENETROMETER VOLUME (cc) ?",Penv
```

```
1995     END IF
2000     PRINT "Penetrometer Volume";Penv;"cc"
2005     REM
2010     REM ************************************
2015     REM Calculate the bulk density of sample:
2020     REM
2025     REM Sample mass / (Penetrometer volume
2030     REM - the volume of mercury actually in
2035     REM   the penetrometer with the sample)
2040     REM ************************************
2045     REM
2050     Bulk_dens=Swt/(Penv-(Eshgpore-Espore)/FNHg_density(Temperature))
2055     Bulk_dens=PROUND(Bulk_dens,-4)
2060     PRINT "Bulk density of sample";Bulk_dens;"g/cc"
2065     REM
2070     REM ****************************
2075     REM Input the penetrometer length
2080     REM ****************************
2085     REM
2090     INPUT "What is the PENETROMETER LENGTH (cm) ?",Penl
2095     PRINT "Penetrometer Length";Penl;"cm"
2100     REM
2105     REM ************************************
2110     REM Input the number of low pressure
2115     REM points and if non zero then input the
2120     REM low pressure intrusion data
2125     REM ************************************
2130     REM
2135     INPUT "How many low pressure points ?",Lp
2140     PRINT "Low pressure points =";Lp
2145     IF Lp THEN
2150       PRINT USING "2/,K,/";"The low pressure intrusion data"
2155       PRINT USING Ti1
2160       FOR I=1 TO Lp
2165         BEEP 1500,.01
2170         PRINT USING "#,2X,2D";I
2175         INPUT "What is the pressure ?",P(I)
2180         PRINT USING "#,12X,2.3D,14X";P(I)
2185         INPUT "What is the intrusion ?",F(I)
2190         PRINT USING "2D.DD";F(I)
2195       NEXT I
2200     END IF
2205 Ti1:IMAGE "NUMBER ",7X,"Pressure ",10X,"Intrusion "
2210     REM
2215     REM *********************************
2220     REM Input the number of times the high
2225     REM pressure readings will be taken
2230     REM *********************************
2235     REM
2240     INPUT "How many cycles ?",Cy
2245     PRINT "Cycles =";Cy
2250     Yes_no("Any corrections ?",Yes)
2255     IF Yes THEN Start
2260     REM
2265     REM ************************************
2270     REM Read how many high pressure points are
2275     REM to be taken (intrusion only) and the
2280     REM high pressure setpoints to be used for
2285     REM both intrusion and extrusion data then
2290     REM calculate the filesize
2300     REM
2315     REM The first data statement is the number
2320     REM of high pressure intrusion data points
2325     REM
2330     REM The second data statement is the
2335     REM actual high pressure intrusion
2340     REM setpoints.
2345     REM
2350     REM NOTE: The extrusion data will be the
2355     REM       intrusion setpoints in reverse
2360     REM       order
2365     REM ************************************
2370     REM
2375     READ Np
2380     REDIM W(1:Np)
2385     READ W(*)
2400 Pts_up:DATA 15
2405     DATA .10,1,2,5,10,20,30,40,50,75,100,125,150,175,200
2410     REM
2415     REM ************************************
```

```
2420     REM Select the correct file size for the
2425     REM data set
2426     REM
2427     REM The first record contains the startup
2428     REM data and the low pressure data points
2429     REM the number of bytes are calulated by:
2430     REM
2432     REM First=The number of 256 byte blocks
2433     REM
2434     REM The subsequent records are the high
2435     REM pressure data arrays plus overhead
2436     REM
2438     REM Filesize=The number of high pressure
2439     REM           points plus overhead in 256
2440     REM           byte blocks
2441     REM ***************************************
2442     REM
2443     First=((Lp*8*2+200) DIV 255)+1
2444     Filesize=((Hp*8*2+20) DIV 255)+1
2445     IF Filesize<=First THEN Filesize=First
2446     REM
2450     REM ***************************************
2455     REM The total number of data points is the
2460     REM low pressure intrusion plus the high
2465     REM pressure intrusion and extrusion data
2470     REM The highest pressure point is the sum
2475     REM of the number of low pressure and the
2480     REM high pressure intrusion points
2485     REM ***************************************
2490     REM
2495     D=Lp+Hp+Hp-1
2500     Hp=Lp+Hp
2505     REM
2510     REM ***************************************
2515     REM You are given the option of a hardcopy
2520     REM of the initial data
2525     REM ***************************************
2530     REM
2535     Yes_no("Do you want a hard copy ?",Yes)
2540     IF Yes THEN
2545       PRINTER IS Hcopy
2550       PRINT USING "K,K,K,50X,K";"There are ";Cy;" cycles",Date$
2555       PRINT USING "K,/";Title$
2560       PRINT USING C1;Swt,Pen_id$
2565       PRINT USING C2;Penv,Scf
2570       PRINT USING C3;Pend,Penl
2575       PRINT USING C4;Hgst,Cona
2580       PRINT USING C5;D,Hp,Lp
2585       PRINT USING C6;Temperature,FNHg_density(Temperature)
2590       PRINT USING C7;Bulk_dens
2595       IF Lp THEN
2600         PRINT USING "K,/";"The low pressure intrusion data"
2605         PRINT USING Ti1
2610         FOR I=1 TO Lp
2615           PRINT USING "2X,2D,12X,Z.3D,14X,2D.2D";I,P(I),F(I)
2620         NEXT I
2625       END IF
2630       PRINT USING "/"
2635     END IF
2640 C1:IMAGE "Sample Mass",15X,2D.4D," g",6X,"Penetrometer Number",4X,10A
2645 C2:IMAGE "Penetrometer Volume",7X,2D.4D," cc",5X,"Stem Conversion Factor",X,DD.DDE,X,"cc/p
2650 C3:IMAGE "Penetrometer Stem Diameter",X,Z.DD,X,"cm",7X,"Penetrometer Length",4X,DD,X,"cm"
2655 C4:IMAGE "Mercury Surface Tension",4X,DDD,X,"dynes/cm",2X,"Contact Angle",10X,3D.D,X,"deg"
2660 C5:IMAGE "Data Points=",3D,5X,"Highest Pressure Reading=",3D,5X,"Low Pressure Reading=",X,
2665 C6:IMAGE "Temperature =",3D.D," deg C",10X,"Mercury density = ",2D.4D," g/cc"
2670 C7:IMAGE /,"Bulk density of sample is ",Z.4D," g/cc",2/
2675     REM
2680     REM ***************************************
2685     REM You are given the chance to store this
2690     REM data as well as the high pressure data
2695     REM to be acquired for future retrival by
2700     REM this program
2705     REM ***************************************
2710     REM
2715     Yes_no("Do you want to store data ?",Yes)
2720     Store=INT(Yes)
2725     IF NOT Store THEN
2730       PRINTER IS Scopy
2735       SUBEXIT
2740     END IF
```

```
2745     REM
2750     REM ****************************************
2755     REM Output the current file name to the
2760     REM operator to modify and enter into the
2765     REM computer
2770     REM
2775     REM NOTE: The mass storage device is
2780     REM       specified by Store$
2785     REM ****************************************
2790     REM
2795 File:OUTPUT 2;File$;
2800     LINPUT "What is the file name ?",File$
2805     REM
2810     REM ****************************************
2815     REM You may now insert the appropriate
2820     REM data media in the stroage device
2825     REM specfied by Store$
2830     REM
2835     REM If there are any problems then the
2840     REM following cases will hopefully cope
2845     REM with them.  They are identified by the
2850     REM return variable Outcome on the assign
2855     REM statement
2860     REM
2865     REM CASE 0
2870     REM
2875     REM If the file exists and is the correct
2880     REM type (BDAT) then the computer will ask
2885     REM if it may overwrite the the data that
2890     REM already exists in the file.
2895     REM NOTE: This will purge the file and
2900     REM       then create it again !!!!!!!
2905     REM
2910     REM CASE 56
2915     REM
2920     REM If the file doesn't exist then it will
2925     REM create the correctly sized BDAT file
2930     REM (BDAT = binary format data )
2935     REM
2940     REM CASE 58
2945     REM
2950     REM If the file exists and is a program
2955     REM type file or an ASCII type file then
2960     REM you must choose another name
2965     REM
2970     REM CASE 53
2975     REM
2980     REM If the filename is too long (more than
2985     REM 10 characters then you will have to
2990     REM input another file name
2995     REM
3000     REM CASE 80
3005     REM
3010     REM If the media isn't installed correctly
3015     REM or if the door is open then correct
3020     REM the problem. Then you will have to
3025     REM input the file name again.
3030     REM
3035     REM CASE 62
3040     REM
3045     REM If the data file exists but is not one
3050     REM created by this program then you will
3055     REM have to input another file name
3060     REM This is done by the security code and
3065     REM is the way the program distinguishes
3070     REM between ASCII and BDAT data files
3075     REM
3080     REM CASE ELSE
3085     REM
3090     REM If there is a fatal error then the
3095     REM the program will stop and you will
3100     REM have to restart the process again.
3105     REM ****************************************
3110     REM
3115     Yes_no("Is the correct data disc installed ?",Yes)
3120     ASSIGN @File TO File$&Security$&Store$;RETURN Outcome
3125     SELECT Outcome
3130     CASE 0
3135       Yes_no("File in existance OVERWRITE DATA ?",Yes)
3140       IF NOT Yes THEN File
```

```
3145      ASSIGN @File TO *
3150      PURGE File$&Security$&Store$
3155      CREATE BDAT File$&Security$&Store$,1+Cy,Filesize*256
3160      ASSIGN @File TO File$&Security$&Store$
3165    CASE 58
3170      PRINT File$&Store$&" is not a data file"
3175      GOTO File
3180    CASE 53
3185      PRINT "Too long a name"
3190      GOTO File
3195    CASE 56
3200      CREATE BDAT File$&Security$&Store$,1+Cy,Filesize*256
3205      ASSIGN @File TO File$&Security$&Store$
3210    CASE 62
3215      PRINT "This is not the correct type of data file"
3220      GOTO File
3225    CASE 80
3230      PRINT "The door is open or media is not installed"
3235      GOTO File
3240    CASE ELSE
3245      PRINT "FATAL ERROR"
3250      PRINT Outcome;" is the error number"
3255      STOP
3260    END SELECT
3265    REM
3270    REM ***********************************
3275    REM The storage file is ready for use
3280    REM ***********************************
3285    REM
3290    PRINT USING "K,/";"The data file is called "&File$&Store$
3295    REM
3300    REM ***************************************
3305    REM Store the initial data set and if any
3310    REM low pressure intrusion data and then
3315    REM the final data set.
3320    REM ***************************************
3325    REM
3330    OUTPUT @File,1;Title$,Date$,Pen_id$,Lp,D,Hp,Temperature
3335    IF Lp THEN
3340      REDIM P(1:Lp),F(1:Lp)
3345      OUTPUT @File;P(*),F(*)
3350      REDIM P(1:D),F(1:D)
3355    END IF
3360    OUTPUT @File;Cy,Penl,Pend,Penv,Hgst,Cona,Scf,Epore,Espore,Eshgpore
3365    PRINTER IS Scopy
3370    REM
3375    REM *********************************
3380    REM End of the subprogram Initialize
3385    REM *********************************
3390    REM
3395  SUBEND
3400  SUB Acquire
3405    REM
3410    REM ***************************************
3415    REM Subprogram Acquire
3420    REM
3425    REM    This is for data acquisition
3430    REM
3435    REM The common declarations are the same
3440    REM as in the main program
3445    REM
3450    REM          LOCAL VARIABLES
3455    REM
3460    REM INTEGER Variables
3465    REM
3470    REM Cyt        The current cycle
3475    REM Store      Flag used if data is to be
3480    REM            stored
3485    REM Maxnumber  The number of high pressure
3490    REM            intrusion data points
3495    REM Timer      The setpoint for the time
3500    REM            between comparisions of
3505    REM            intrusion readings (seconds)
3510    REM Yes        Either set to 0 (false) or
3515    REM            1 (true)
3520    REM I,J        Counters for FOR..NEXT loops
3525    REM
3530    REM REAL Variables
3535    REM
3540    REM W(*)        The array for high pressure
```

```
3545     REM              setpoints
3550     REM Apparent_d The apparent density of the
3555     REM              sample
3560     REM
3565     REM DYNAMIC ALLOCATION
3570     REM
3575     REM P1(*)      The array for high pressure
3580     REM            values
3585     REM F1(*)      The array for high pressure
3590     REM            intrusion values
3595     REM ************************************
3600     REM
3605     COM /Poresimeter/ INTEGER Slot,Up,Down,Pressure,Intrusion,@Poresimeter
3610     COM /Read/ Mpa,Pf,Timeit,Reader
3615     COM /Constants/ INTEGER Hcopy,Scopy,Splot,Hplot,Datalogger
3620     COM /Constants/ Splot$,Hplot$,Store$,Prog$,Security$
3625     COM /Analyse/ Temperature,Penl,Pend,Penv,Hgst,Cona,Scf
3630     COM /Analyse/ INTEGER D,Hp,Lp,Cy
3635     COM /Analyse/ Date$,Title$,Swt,Pen_id$,P(*),F(*)
3640     COM /Analyse/ Epore,Espore,Eshgpore
3645     INTEGER Cyt,Store,Timer,Maxnumber,Yes
3650     DIM W(1:100)
3655     REM
3660     REM *************
3665     REM Set constants
3670     REM *************
3675     REM
3680     ASSIGN @Poresimeter TO Datalogger
3685     READ Slot,Up,Down,Pressure,Intrusion,Timer,Reader
3690 Datalog:DATA 3,0,1,1,0,30,.25
3695     REM
3700     REM ***********************************
3705     REM Setup system for data acquisition
3710     REM ***********************************
3715     REM
3720     PRINTER IS CRT      ! The internal CRT
3725     GCLEAR
3730     GRAPHICS OFF
3735     ALPHA ON
3740     OUTPUT 2 USING "#,B";255,75 !clear screen
3745     REM
3750     REM ****************************************
3755     REM Get the initial data and setpoints for
3760     REM the high pressure readings
3765     REM ****************************************
3770     REM
3775     Initialize(W(*),@File,Store)
3780     ALLOCATE P1(1:D-Lp),F1(1:D-Lp)
3785     Maxnumber=Hp-Lp
3790 Set_up:Yes_no("Is the poresimeter set up correctly ?",Yes)
3795     IF NOT Yes THEN SUBEXIT
3800     REM
3805     REM ****************************************
3810     REM To abort any time press KEY 4 to abort
3815     REM the run.  You will not store that or
3820     REM any future cycle of the run
3825     REM ****************************************
3830     REM
3835     ON KEY 4 LABEL "ABORT" RECOVER Abort
3840     REM
3845     REM ****************************************
3850     REM For each cycle the following things
3855     REM happen.
3860     REM
3865     REM 1. The internal CRT is cleared
3870     REM 2. The high pressure arrays are set to
3875     REM    zero
3880     REM 3. The poresimeter is run to collect
3885     REM    the high intrusion and extrusion
3890     REM    data for the current cycle 'Cyt'
3895     REM 4. The apparent density is calculated
3900     REM    from the highest pressure reading
3905     REM    and printed on the hard copy device
3910     REM 5. The data is stored on disc if flag
3915     REM    is set
3920     REM ****************************************
3925     REM
3926     PRINTER IS CRT
3930     FOR Cyt=1 TO Cy
3935       OUTPUT 2 USING "#,B";255,75!clear screen
```

```
3940      MAT F1= (0)
3945      MAT P1= (0)
3950      Poresimeter(W(*),P1(*),F1(*),Maxnumber,Cyt,Timer,Lp)
3955      IF F1(Hp-Lp) THEN
3960        Apparent_d=Swt/(Penv-(Eshgpore-Espore)/FNHg_density(Temperature)-(F1(1)-F1(Hp-Lp))*
3965        OUTPUT Hcopy USING Tt;P1(Hp-Lp),Apparent_d
3970 Tt:     IMAGE /,"The apparent density at ",3D.2D," MPa is ",Z.4D," g/cc"
3975      END IF
3980      OUTPUT Hcopy USING "#,@" ! form feed
3985      IF Store THEN OUTPUT @File,1+Cyt;P1(*),F1(*)
3990    NEXT Cyt
3995    REM
4000    REM ****************************************
4005    REM Clear the soft copy screen and exit
4010    REM the subprogram.  Successful end of run
4015    REM ****************************************
4020    REM
4025    OUTPUT 2 USING "#,B";255,75  !clear screen
4030    SUBEXIT
4035    REM
4040    REM ****************************************
4045    REM *            Operator abort            *
4050    REM ****************************************
4055    REM
4060    REM ****************************************
4065    REM Poresimeter is turned off where ever
4070    REM it is and the data logger is reset by
4075    REM calling the subprogram Abort
4080    REM
4085    REM NOTE: Power is still on !!!!!!!!
4090    REM
4095    REM The data file is closed and the
4100    REM computer will beep to let the operator
4105    REM know it has done something
4110    REM ****************************************
4115    REM
4120 Abort:Abort
4125    IF Store THEN ASSIGN @File TO *
4130    OUTPUT Hcopy USING "/,K,3/";"****  Operator abort  ****"
4135    FOR J=1 TO 8
4140      FOR I=1 TO 5
4145        BEEP I*400,.01
4150      NEXT I
4155      FOR I=4 TO 2 STEP -1
4160        BEEP I*400,.01
4165      NEXT I
4170    NEXT J
4175    PRINTER IS CRT
4180    OUTPUT 2 USING "#,B";255,75  !clear screen
4185    OFF KEY
4190    OFF CYCLE
4195    REM
4200    REM ****************************
4205    REM End of the subprogram Acquire
4210    REM ****************************
4215    REM
4220  SUBEND
4225  SUB Poresimeter(P(*),Pres(*),Intrus(*),INTEGER Maxnumber,Cy,Timer,Lp)
4230    REM
4235    REM ****************************************
4240    REM Subprogram Poresimeter
4245    REM
4250    REM REAL ARRAYS
4255    REM
4260    REM P(*)       the array of high pressure
4265    REM            setpoints
4270    REM Pres(*)    The array of actual high
4275    REM            pressure data points
4280    REM Intrus(*)  The array of actual high
4285    REM            pressure intrusion and
4290    REM            extrusion data points
4295    REM
4300    REM INTEGER VARIABLES
4305    REM
4310    REM Maxnumber The number of high pressure
4315    REM           intrusion setpoints
4320    REM Cy        The current cycle the run is
4325    REM           operating on
4330    REM Timer     The time between comparison
4335    REM           of the intrusion data points
```

```
4340     REM Lp          The number of low pressure
4345     REM             points
4350     REM
4355     REM Common declarations are the same as
4360     REM the main program
4365     REM
4370     REM              LOCAL VARIABLES
4381     REM
4383     REM INTEGER VARIABLES
4385     REM
4390     REM J           The current setpoint being
4395     REM             worked on
4400     REM C           The number of concurrent
4405     REM             intrusion readings taken
4410     REM             If it is greater than 2 then
4415     REM             it will compare the array
4420     REM             Inter(*) to see if the
4425     REM             poresimeter has stabilized
4430     REM Redcount    The number of readings taken
4435     REM             at each setpoint
4440     REM Dwner       Flag if in the compression
4445     REM             or decompression mode
4450     REM Ups         Flag if the pressure switch
4455     REM             is in the up mode
4460     REM Dwn         Flag if the pressure switch
4465     REM             is in the down mode
4470     REM Around      Flagged if the intrusion and
4475     REM             pressure readings are to be
4480     REM             considered valid
4485     REM Off         Flagged if the switch is off
4490     REM
4495     REM DYNAMICALLY ALLOCATED ARRAYS
4500     REM
4505     REM Inter(*)    Real array for the three
4510     REM             comparison values of the
4515     REM             intrusion values
4520     REM ****************************************
4525     REM
4530     COM /Poresimeter/ INTEGER Slot,Up,Down,Pressure,Intrusion,@Poresimeter
4535     COM /Read/ Mpa,Pf,Timeit,Reader
4540     COM /Constants/ INTEGER Hcopy,Scopy,Splot,Hplot,Datalogger
4545     COM /Constants/ Splot$,Hplot$,Store$,Prog$,Security$
4550     ALLOCATE Inter(1:3)
4555     INTEGER J,C,Redcount,Ups,Dwn,Dwner,Around,Off
4560     REM
4565     REM ************************************
4570     REM The printer is set to the CRT screen
4575     REM This is done because of the control
4580     REM statements in the sub Printit
4585     REM ************************************
4590     REM
4595     PRINTER IS CRT
4600     Redcount=0
4605     REM
4610     REM ************************************
4615     REM Start up the run by subprogram Setup
4620     REM which initializes datalogger
4625     REM ************************************
4630     REM
4635 Start:Setup
4640     REM
4645     REM ************************************
4650     REM Set up the soft copy display of run
4655     REM time data
4660     REM ************************************
4665     REM
4670     PRINT USING Title1;DATE$(TIMEDATE),Cy,TIME$(TIMEDATE)
4675     PRINT USING Title2
4680     PRINT USING Title3
4685     PRINT USING Title4;Timer
4690     PRINT USING Title5
4695 Title1:IMAGE @,11A,7X,"Cycle ",2D,16X,8A
4700 Title2:IMAGE /,"Current Pressure",8X,"MPa",3X,"Setpoint",8X,"MPa",/,8X,"Intrusion",7X,"p
4705 Title3:IMAGE /,"Intrusion Data   Active  Time since",/,25X,"Last Reading",5X,"seconds"
4710 Title4:IMAGE /,25X,"Period between",/,11X,"Cycle",9X,"Readings",5X,3D," seconds"
4715 Title5:IMAGE /,25X,"Number of",/,25X,"readings"
4720     REM
4725     REM ************************************
4730     REM         The compression cycle
4735     REM
```

```
4740     REM The current pressure and intrusion
4745     REM values are read by the subprogram READ
4750     REM The length of time is set by Reader
4755     REM
4760     REM The controlling is done by subprogram
4765     REM SWITCH. It will turn the high pressure
4770     REM switch to the up, down or off position
4775     REM depending on the current setpoint.
4780     REM
4785     REM While the pressure is lower than the
4790     REM first setpoint the flag Around is set
4795     REM so no data is collected.
4800     REM
4805     REM The display is updated every pass
4810     REM of the loop
4815     REM ****************************************
4820     REM
4825     ON CYCLE Reader CALL Read
4830     WHILE Mpa>P(1)+.1
4835       Switch(2)
4840       Around=0
4845       Timeit=0
4850       GOSUB Printit
4855     END WHILE
4860     REM
4865     REM ******************************
4870     REM Turn off the pressure switch
4875     REM ******************************
4880     REM
4885     Switch(3)
4890     REM
4895     REM ***************************************
4900     REM set counter J to first setpoint
4905     REM              C to 1 for the array
4910     REM              Inter(*)
4915     REM set flag Ups  -Up switch is off
4920     REM          Dwner -Compression cycle
4925     REM ***************************************
4930     REM
4935     J=1
4940     Ups=0
4945     Dwner=0
4950     C=1
4955     REM
4960     REM ************************************
4965     REM Print out the hardcopy for the cycle
4970     REM ************************************
4975     REM
4980     OUTPUT Hcopy USING Cyt;Cy
4985 Cyt:IMAGE 7X,5("*"),5X,"For cycle number ",2D,5X,5("*")
4990     OUTPUT Hcopy USING Ti1
4995 Ti1:IMAGE "NUMBER ",7X,"Pressure ",10X,"Intrusion ","Number of readings"
5000     OUTPUT Hcopy;"COMPRESSION DATA"
5005     REM
5010     REM ************************************
5015     REM The compression data collection loop
5020     REM ************************************
5025     REM
5030     LOOP
5035       REM
5040       REM **********************************
5045       REM If the time counter is equal or
5050       REM greater than the time period then
5055       REM take a reading for comparison
5060       REM **********************************
5065       REM
5070       IF Timeit>Timer THEN
5075         Timeit=0
5080         GOSUB Around
5085       END IF
5090     EXIT IF J>Maxnumber
5095       REM
5100       REM ****************************
5105       REM Move to column 40 and row 3
5110       REM Print the current setpoint
5115       REM ****************************
5120       REM
5125       CONTROL 1,0;40        ! COL 40
5130       CONTROL 1,1;3         ! ROW 3
5135       PRINT USING "3D.2D";P(J)
```

```
5140      REM
5145      REM ************************************
5150      REM Using the current pressure reading:
5155      REM
5160      REM 1. If it is greater than or equal to
5165      REM    the setpoint then turn the switch
5170      REM    to off
5175      REM
5180      REM 2. If it is less than the current
5185      REM    setpoint then turn the switch to
5190      REM    up
5195      REM ************************************
5200      REM
5205      SELECT Mpa
5210      CASE >=P(J)
5215        REM
5220        REM ********************************
5225        REM If the switch is in the up mode
5230        REM then turn it off
5235        REM ********************************
5240        REM
5245        IF Ups THEN
5250          Switch(3)
5255          Around=1
5260          Ups=0
5265        END IF
5270      CASE <P(J)
5275        REM
5280        REM ********************************
5285        REM If the switch is off then turn it
5290        REM on and disable comparison
5295        REM ********************************
5300        REM
5305        IF NOT Ups THEN
5310          Ups=1
5315          Switch(1)
5320          Around=0
5325        END IF
5330      END SELECT
5335      GOSUB Printit
5340      REM
5345      REM ************************************
5350      REM Update the screen with current data
5355      REM ************************************
5360      REM
5365    EXIT IF J>Maxnumber
5370      REM
5375      REM ********************************
5380      REM If the pressure is too low then
5385      REM disable the time counter
5390      REM ********************************
5395      REM
5400      IF Mpa<=P(J)-.2 THEN Timeit=0
5405    END LOOP
5410    REM
5415    REM ************************************
5420    REM       END OF COMPRESSION CYCLE
5425    REM Turn off the periodic cycle interupt
5430    REM and get ready for the decompression
5435    REM cycle
5440    REM ************************************
5445    REM
5450    OFF CYCLE
5455    REM
5460    REM ************************
5465    REM The decompression cycle
5470    REM ************************
5475    REM
5480    OUTPUT Hcopy;"DECOMPRESSION DATA"
5485    REM
5490    REM ****************************************
5495    REM Set up periodic updating of pressure
5500    REM and intrusion (time defined by Reader)
5505    REM ****************************************
5510    REM
5515    ON CYCLE Reader CALL Read
5520    REM
5525    REM ************************************
5530    REM Dwner is set to indicate decompression
5535    REM J     is set to indicate the first
```

```
5540     REM         point of the decompression cycle
5545     REM C       is set to first reading to be
5550     REM         saved in the comparison array
5555     REM Dwn     is set for the correct switch to
5560     REM         be set in loop
5565     REM Redcount is set to zero for number of
5570     REM          readings at that setpoint
5575     REM ***************************************
5580     REM
5585     J=1
5590     Dwn=0
5595     Dwner=1
5600     C=1
5605     Redcount=0
5610     LOOP
5615       REM
5620       REM ***************************************
5625       REM If the time of the reading is equal
5630       REM to the setpoint then take the
5635       REM reading for comparision.
5640       REM ***************************************
5645       REM
5650       IF Timeit>Timer THEN
5655         Timeit=0
5660         GOSUB Around
5665       END IF
5670     EXIT IF Maxnumber-J<1
5675       REM
5680       REM ***********************************
5685       REM Display the current set point used
5690       REM ***********************************
5695       REM
5700       CONTROL 1,0;40        ! COL 40
5705       CONTROL 1,1;3         ! ROW 3
5710       PRINT USING "3D.2D";P(Maxnumber-J)
5715       REM
5720       REM ***************************************
5725       REM Using the current pressure reading:
5730       REM
5735       REM 1. If it is greater than the current
5740       REM    setpoint then turn the switch to
5745       REM    down
5750       REM
5755       REM 2. If it is lower than the setpoint
5760       REM    -.1 then turn the switch to up
5765       REM
5770       REM 3. If it is lower than the setpoint
5775       REM    then turn the switch to off
5780       REM ***************************************
5785       REM
5790       SELECT Mpa
5795       CASE >P(Maxnumber-J)
5800         REM
5805         REM *********************************
5810         REM If the switch is not set to down
5815         REM then disable taking of readings
5820         REM and set Off to false and Dwn to
5825         REM true otherwise ignore
5830         REM *********************************
5835         REM
5840         IF NOT Dwn THEN
5845           Switch(2)
5850           Around=0
5855           Off=0
5860           Dwn=1
5865         END IF
5870       CASE <=P(Maxnumber-J)-.1
5875         REM
5880         REM *********************************
5885         REM If the switch is already down then
5890         REM disable comparison set Off and Dwn
5895         REM to false and turn the switch to up
5900         REM *********************************
5905         REM
5910         IF Dwn THEN
5915           Around=0
5920           Off=0
5925           Dwn=0
5930           Switch(1)
5935         END IF
```

```
5940      CASE <=P(Maxnumber-J)
5945        REM
5950        REM ***********************************
5955        REM If the switch is not off then turn
5960        REM it off;enable the readings;set Off
5965        REM to true and Dwn to false
5970        REM ***********************************
5975        REM
5980        IF NOT Off THEN
5985          Off=1
5990          Dwn=0
5995          Switch(3)
6000          Around=1
6005        END IF
6010      END SELECT
6015      REM
6020      REM ***********************************
6025      REM Update the screen with current data
6030      REM ***********************************
6035      REM
6040      GOSUB Printit
6045      REM
6050      REM *********************************
6055      REM If the current pressure is higher
6060      REM than the setpoint+0.2 then don't
6065      REM take any readings
6070      REM *********************************
6075      REM
6080      IF Mpa>P(Maxnumber-J)+.2 THEN Timeit=0
6085    END LOOP
6090    REM
6095    REM ****************************************
6100    REM Normal finish goto the cleanup section
6105    REM ****************************************
6110    REM
6115    GOTO Exit
6120 Printit:DISABLE
6125    REM
6130    REM ***************************************
6135    REM Disable interupts
6140    REM Move to column 43 and row 1
6145    REM Update the time
6150    REM ***************************************
6155    REM
6160    PRINT TABXY(43,1);TIME$(TIMEDATE)
6165    REM
6170    REM ***********************************
6175    REM Move to column 18 row 3
6180    REM Print current high pressure reading
6185    REM ***********************************
6190    REM
6195    CONTROL 1,0;18          ! COL 18
6200    CONTROL 1,1;3           ! ROW 3
6205    PRINT USING "3D.2D";Mpa
6210    REM
6215    REM *********************************
6220    REM Move to column 19 and row 4
6225    REM Print current intrusion reading
6230    REM *********************************
6235    REM
6240    CONTROL 1,1;4           ! ROW 4
6245    CONTROL 1,0;19          ! COL 19
6250    PRINT USING "2D.2D";Pf
6255    REM
6260    REM ***************************************
6265    REM move to column 1 and row 7
6270    REM If the flag Around is enabled then
6275    REM print the comparison readings and time
6280    REM since the last reading otherwise
6285    REM don't print them
6290    REM ***************************************
6295    REM
6300    CONTROL 1,1;7           ! ROW 7
6305    IF Around THEN
6310      PRINT USING "X,2D.DD,2X,2D.2D,5X,3A";Inter(1),Inter(2),"YES"
6315      CONTROL 1,0;39        ! COL 35
6320      CONTROL 1,1;7         ! ROW 7
6325      PRINT USING "3D";Timeit
6330    ELSE
6335      PRINT USING "X,17X,3A";" NO"
```

```
6340      CONTROL 1,0;39        ! COL 35
6345      CONTROL 1,1;7         ! ROW 7
6350      PRINT USING "3A";"***"
6355    END IF
6360    REM
6365    REM ****************************************
6370    REM Print if in the intrusion or extrusion
6375    REM cycle
6380    REM ****************************************
6385    REM
6390    IF NOT Dwner THEN PRINT TABXY(2,10);"Intrusion"
6395    IF Dwner THEN PRINT TABXY(2,10);"Extrusion"
6400    REM
6405    REM ****************************************
6410    REM Move to column 35 and row 13
6415    REM Print the number of readings taken at
6420    REM the current setpoint
6425    REM ****************************************
6430    REM
6435    CONTROL 1,1;13            ! ROW 13
6440    CONTROL 1,0;35            ! COL 35
6445    PRINT USING "3D";Redcount
6450    ENABLE
6455    RETURN
6460 Around:DISABLE
6465    REM
6470    REM ****************************************
6475    REM Disable interupts and if Around is set
6480    REM increment Redcount and get the current
6485    REM intrusion using FNIntrusion
6490    REM Increment the number of values to be
6495    REM compared at the current setpoint
6500    REM ****************************************
6505    REM
6510    IF Around THEN
6515      Redcount=Redcount+1
6520      Inter(C)=FNIntrusion
6525      C=C+1
6530      IF C>3 THEN
6535        REM
6540        REM ***********************************
6545        REM If all the intrusion readings are
6550        REM all the same then take the current
6555        REM intrusion and pressure readings
6560        REM then move on the the next setpoint
6565        REM ***********************************
6570        REM
6575        IF Inter(1)=Inter(2) AND Inter(1)=Inter(3) THEN
6580          GOSUB Take
6585        ELSE
6590          REM
6595          REM *********************************
6600          REM Shuffle the array down and wait
6605          REM for the next value to compare to
6610          REM *********************************
6615          REM
6620          Inter(1)=Inter(2)
6625          Inter(2)=Inter(3)
6630          Inter(3)=0
6635          C=3
6640        END IF
6645      END IF
6650    END IF
6655    ENABLE
6660    RETURN
6665    REM
6670    REM ********************
6675    REM Enable the interupts
6680    REM End of sub Around
6685    REM ********************
6690    REM
6695 Take:C=1
6700    Around=0
6705    REM
6710    REM ************************************
6715    REM Reset flags and insert the current
6720    REM values in the arrays Pres(*) and
6725    REM Intrus(*).  Output the values to the
6730    REM hardcopy printer and increment the
6735    REM setpoint counter. Zero the number
```

```
6740     REM of readings taken at that setpoint
6745     REM and the array used to hold them
6750     REM ************************************
6755     REM
6760     IF Dwner THEN
6765       Pres(J+Maxnumber)=FNPressure
6770       Intrus(J+Maxnumber)=FNIntrusion
6775       OUTPUT Hcopy USING D;J+Maxnumber+Lp,Pres(J+Maxnumber),Intrus(J+Maxnumber),Redcount
6780     ELSE
6785       Pres(J)=FNPressure
6790       Intrus(J)=FNIntrusion
6795       OUTPUT Hcopy USING D;J+Lp,Pres(J),Intrus(J),Redcount
6800     END IF
6805     J=J+1
6810     Redcount=0
6815     MAT Inter= (0)
6820     RETURN
6825     REM
6830     REM ******************
6835     REM End of the sub Take
6840     REM ******************
6845     REM
6850 D: IMAGE 2X,2D,11X,3D.2D,14X,2D.2D,6X,3D
6855     REM
6860     REM ************************************
6865     REM The special function keys are disabled
6870     REM for interupts
6875     REM The shutdown sequence is handled by
6880     REM the subprogram Shutdown
6885     REM The periodic interupt is cancelled
6890     REM ************************************
6895     REM
6900 Exit:OFF KEY
6905     PRINT USING "@,K";"SHUT DOWN SEQUENCE UNDER WAY PLEASE DON'T TOUCH"
6910     Shutdown
6915     OFF CYCLE
6920   SUBEND
6925     REM
6930     REM ******************************
6935     REM End of subprogram Poresimeter
6940     REM ******************************
6945     REM
6950   SUB Setup
6955     REM
6960     REM ************************************
6965     REM Subprogram Setup
6970     REM
6975     REM This clears the datalogger and then
6980     REM sets it up for data acquisition and
6985     REM control of poresimeter
6990     REM
6995     REM The common declarations are the same
7000     REM in the main program
7005     REM
7010     REM Datalogger commands
7015     REM
7020     REM VA1  - Auto zero enabled
7025     REM VD5  - use 5.5 digits
7030     REM VF1  - ASCII format
7035     REM VR3  - 10 Volt range
7040     REM VN1  - take one reading
7045     REM VT1  - Internal trigger
7050     REM SD0  - display nothing
7055     REM ************************************
7060     REM
7065     COM /Poresimeter/ INTEGER Slot,Up,Down,Pressure,Intrusion,@Poresimeter
7070     CLEAR @Poresimeter
7075     OUTPUT @Poresimeter;"VA1VD5VF1VR3VN1VT1SD0"
7080     REM
7085     REM ************************
7090     REM End of subprogram Setup
7095     REM ************************
7100     REM
7105   SUBEND
7110   SUB Shutdown
7115     REM
7120     REM ************************************
7125     REM Subprogram Shutdown
7130     REM
7135     REM This provides an orderly shutdown of
```

```
7140    REM datalogger and poresimeter
7145    REM
7150    REM The common declarations are the same
7155    REM as in the main program
7160    REM
7165    REM Datalogger commands
7170    REM
7175    REM TD          Display time and date
7180    REM ****************************************
7185    REM
7190    COM /Poresimeter/ INTEGER Slot,Up,Down,Pressure,Intrusion,@Poresimeter
7195    COM /Read/ Mpa,Pf,Timeit,Reader
7200    REM
7205    REM ****************************************
7210    REM Enable the down switch and wait until
7215    REM the pressure is less than 0.1 MPa and
7220    REM continue executing the rest of the
7225    REM subprogram
7230    REM NOTE: The pressure transducer will
7235    REM       fluctuate and this may not allow
7240    REM       the loop to ever be exited !!!
7245    REM       To escape just adjust the the
7250    REM       transducer to less than 0.1 and
7255    REM       then the program will continue
7260    REM ****************************************
7265    REM
7270    Switch(2)
7275    REPEAT
7280    UNTIL Mpa<=.10
7285    REM
7290    REM ****************************************
7295    REM Clear the poresimeter to default
7300    REM conditions and have it display the
7305    REM current date then let it have local
7310    REM control
7315    REM ****************************************
7320    REM
7325    CLEAR @Poresimeter
7330    OUTPUT @Poresimeter;"TD"
7335    LOCAL @Poresimeter
7340    REM
7345    REM ***************************
7350    REM End of subprogram Shutdown
7355    REM ***************************
7360    REM
7365  SUBEND
7370  SUB Switch(INTEGER Choice)
7375    REM
7380    REM ****************************************
7385    REM Subprogram Switch
7390    REM
7395    REM Controls the up and down switch of the
7400    REM poresimeter
7405    REM
7410    REM The common declarations are the same
7415    REM as the main program
7420    REM
7425    REM Choice  - 1 energizes up relay
7430    REM             de-energizes down relay
7435    REM           2 energizes down relay
7440    REM             de-energizes up relay
7445    REM           3 de-energizes up relay
7450    REM             de-energizes down relay
7455    REM
7460    REM Datalogger commands
7465    REM
7470    REM DO  - Open the actuator relay
7475    REM DC  - Close the actuator relay
7480    REM ****************************************
7485    REM
7490    COM /Poresimeter/ INTEGER Slot,Up,Down,Pressure,Intrusion,@Poresimeter
7495    SELECT Choice
7500    CASE 1  !   UP
7505      OUTPUT @Poresimeter USING T;"DO",Slot,Down
7510      OUTPUT @Poresimeter USING T;"DC",Slot,Up
7515    CASE 2  !   DOWN
7520      OUTPUT @Poresimeter USING T;"DC",Slot,Down
7525      OUTPUT @Poresimeter USING T;"DO",Slot,Up
7530    CASE 3  !   OFF
7535      OUTPUT @Poresimeter USING T;"DO",Slot,Down
```

```
7540      OUTPUT @Poresimeter USING T;"DO",Slot,Up
7545    CASE ELSE
7550    END SELECT
7555 T: IMAGE 2A,DD,",",DD
7560    REM
7565    REM ************************
7570    REM End of subprogram Switch
7575    REM ************************
7580    REM
7585  SUBEND
7590  SUB Read
7595    REM
7600    REM ************************************
7605    REM Subprogram Read
7610    REM
7615    REM Retrieves the current high pressure
7620    REM and intrusion readings from the
7625    REM poresimeter
7630    REM
7635    REM The common declarations are the same
7640    REM as in the main program
7645    REM ************************************
7650    REM
7655    COM /Poresimeter/ INTEGER Slot,Up,Down,Pressure,Intrusion,@Poresimeter
7660    COM /Read/ Mpa,Pf,Timeit,Reader
7665    REM
7670    REM ************************************
7675    REM The function FNPressure gets the
7680    REM current high pressure and the function
7685    REM FNIntrusion gets the current intrusion
7690    REM readings both functions return the
7695    REM variables in the form of engineering
7700    REM units (MPa and pF)
7705    REM The time counter is incremented by the
7710    REM same amount as the cycle interupt time
7715    REM defined by Reader
7720    REM ************************************
7725    REM
7730    Mpa=FNPressure
7735    Pf=FNIntrusion
7740    Timeit=Timeit+Reader
7745    REM
7750    REM ************************
7755    REM End of subprogram Read
7760    REM ************************
7765    REM
7770  SUBEND
7775  SUB Yes_no(Prompt$,INTEGER Yes)
7780    REM
7785    REM ************************************
7790    REM Subprogram Yes_no
7795    REM
7800    REM Returns a true or false value to
7805    REM the calling program
7810    REM
7815    REM Prompt$ - contains the prompt to be
7820    REM           displayed by the computer
7825    REM Yes     - contains either a zero for
7830    REM           false or a one for true
7835    REM
7840    REM The special function keys are used to
7845    REM make the choice. After the choice has
7850    REM been made the computer will clean up
7855    REM ************************************
7860    REM
7865    DISP Prompt$
7870    Yes=0
7875    ON KEY 0 LABEL " Yes" GOTO Yes
7880    ON KEY 1 LABEL "  No" GOTO Exit
7885    BEEP 2200,.01
7890 Idle:GOTO Idle
7895 Yes:Yes=1
7900 Exit:DISP
7905    OFF KEY
7910    REM
7915    REM ************************
7920    REM End of subprogram Yes_no
7925    REM ************************
7930    REM
7935  SUBEND
```

```
7940  SUB Pauser
7945    REM
7950    REM ****************************************
7955    REM Subprogram Pauser
7960    REM
7965    REM The only way to exit this section is
7970    REM press key 0.  This will allow the user
7975    REM to view graphics displays without any
7980    REM alphanumeric displays interfering or
7985    REM if just a pause in the program is
7990    REM desired
7995    REM ****************************************
8000    REM
8005    BEEP 500,.01
8010    ON KEY 0 LABEL "Continue" GOTO Exit
8015 Idle:GOTO Idle
8020 Exit:OFF KEY
8025    GRAPHICS OFF
8030    ALPHA ON
8035    REM
8040    REM *************************
8045    REM End of subprogram Pauser
8050    REM *************************
8055    REM
8060  SUBEND
8065  SUB Analyse
8070    REM
8075    REM ****************************************
8080    REM Subprogram Analyse
8085    REM
8090    REM The data collected by this program or
8095    REM data input by the user will be
8100    REM analysed graphically as well as a hard
8105    REM copy of the tables used
8110    REM
8115    REM The common declarations are the same
8120    REM as in the main program
8125    REM
8130    REM           LOCAL VARIABLES
8135    REM
8140    REM CHARACTER ARRAYS
8145    REM
8150    REM Log_$(*)[10] Labels of the log scale
8155    REM
8160    REM CHARACTER variables
8165    REM
8170    REM Pp$[9]      For printing overline with
8175    REM             the character 'P'
8180    REM Dd$[9]      For printing overline with
8185    REM             the character 'D'
8190    REM Ol$[4]      The escape sequence to use
8195    REM             with HP9876A printer to
8200    REM             start overlining characters
8205    REM Nol$[4]     The escape sequence to use
8210    REM             with HP9876A printer to
8215    REM             halt the overlining of
8220    REM             characters
8225    REM
8230    REM INTEGER VARIABLES
8235    REM
8240    REM Man         Set to true to manually
8245    REM             input data to analyse
8250    REM Cyt         Which cycle is being
8255    REM             analysed
8260    REM Printer     Select code of the printer
8265    REM             in use
8270    REM Yes         Either set to 1 (true) or
8275    REM             0 (false)
8280    REM Copy        If an 80 column printer or
8285    REM             screen then full tables are
8290    REM             printed
8295    REM Branch      Which semi-log curve is
8300    REM             being worked on
8305    REM Hplotter    Set to 1 if hardcopy plotter
8310    REM             is being use otherwise 0
8315    REM Log_interval How many decades are to
8320    REM                 used in semi-log plot
8325    REM Decade      Counter while drawing the
8330    REM             semi-log plot
8335    REM Interval    counter while drawing the
```

```
8340    REM              semi-log plot
8345    REM I            Counter for FOR..NEXT loops
8350    REM P1x          Used to get hard clip limits
8355    REM P2x          coordinates from the plotter
8360    REM P1y          and output to plotter after
8365    REM P2y          the plot is finished
8370    REM
8375    REM REAL VARIABLES
8380    REM
8385    REM Apparent_d The apparent density of
8390    REM              sample at a given pressure
8395    REM Bulk_dens  The bulk density of the
8400    REM              sample at room pressure
8405    REM Pc0          The constant Po
8410    REM P0v0         The constant Po/Vo
8415    REM Cutoff       The cutoff pressure for
8420    REM              linear portion of the
8425    REM              pressure vs area curve
8430    REM Maximum      The maximum value of an
8435    REM              array
8440    REM Xmin         The minimum value for the
8445    REM              X axis
8450    REM Xmax         The maximum value for the
8455    REM              X axis
8460    REM Ymin         The minimum value for the
8465    REM              Y axis
8470    REM Ymax         The maximum value for the
8475    REM              Y axis
8480    REM Y_axis       Counter used in labeling
8485    REM              Y axis
8490    REM Yscale       The space for y-axis labels
8495    REM Xscale       The space for x-axis labels
8500    REM Xtick        The distance between tick
8505    REM              marks on x-axis
8510    REM Ytick        The distance between tick
8515    REM              marks on y-axis
8520    REM
8525    REM DYNAMICALLY ALLOCATED
8530    REM
8535    REM Dav(*)         Average pore diameter
8540    REM Pav(*)         Average pressure
8545    REM Deltav(*)      Change in pore volume
8550    REM Pdv(*)         Average pressure times the
8555    REM                change in pore volume
8560    REM Sumpdv(*)      The cumulative total of
8565    REM                Pdv(*)
8570    REM A_(*)          The area of the sample in
8575    REM                m^2/g
8580    REM Percenta(*)    The cumulative per cent
8585    REM                area of the sample
8590    REM Cumv(*)        The cumulative pore volume
8595    REM                in cc
8600    REM Pored(*)       The pore diameter (um)
8605    REM Pcorr(*)       The corrected pressure
8610    REM Porev(*)       The cumulative pore volume
8615    REM                in cc/g
8620    REM P1(*)          The high pressure array
8625    REM F1(*)          The high pressure
8630    REM                intrusion array
8635    REM
8640    REM I/O Paths
8645    REM
8650    REM @File          The computer - data file
8655    REM                connection
8660    REM ****************************************
8665    REM
8670    COM /Constants/ INTEGER Hcopy,Scopy,Splot,Hplot,Datalogger
8675    COM /Constants/ Splot$,Hplot$,Store$,Prog$,Security$
8680    COM /Analyse/ Temperature,Penl,Pend,Penv,Hgst,Cona,Scf
8685    COM /Analyse/ INTEGER D,Hp,Lp,Cy
8690    COM /Analyse/ Date$,Title$,Swt,Pen_id$,P(*),F(*)
8695    COM /Analyse/ Epore,Espore,Esh&pore
8700    DIM Log_$(1:7)[5],Pp$[9],Dd$[9],Ol$[4],Wol$[4]
8705    INTEGER Cyt,Printer,Yes,Copy,Branch,Hplotter,Log_interval,Decade,Interval
8710    INTEGER I,Man,P1x,P1y,P2x,P2y
8715    REAL Apparent_d,Bulk_dens,Pc0,P0v0,Cutoff,Maximum,Density
8720    REAL Xmax,Ymax,Xmin,Ymin,Y_axis,Xscale,Yscale,Ytick,Xtick
8725    REM
8730    REM ****************************************
8735    REM Input data manually answer yes
```

```
8740     REM Input data from a data file answer no
8745     REM ************************************
8750     Yes_no("Manually input data ?",Man)
8755     IF Man THEN CALL Mandata
8760     IF NOT Man THEN CALL Filedata(@File)
8765     REM
8770     REM ************************************
8775     REM Allocate the arrays for analysis
8780     REM ************************************
8785     REM
8790     ALLOCATE Dav(1:D),Pav(1:D),Deltv(1:D),Pdv(1:D),Sumpdv(1:D),A_(1:D),Percenta(1:D)
8795     ALLOCATE Cumv(1:D),Pored(1:D),Pcorr(1:D),Porev(1:D)
8800     ALLOCATE P1(1:D-Lp),F1(1:D-Lp)
8805     REM
8810     REM ************************************
8815     REM If data is to be got from a data file
8820     REM then input the cycle to be looked at
8825     REM and get the appropiate high pressure
8830     REM set from the file I/O path @File
8835     REM ************************************
8840     REM
8845 Res:IF NOT Man THEN
8850       PRINT "There are ";Cy;"cycles to look at"
8855       INPUT "Which cycle do you want to look at ?",Cyt
8860       IF Cyt<1 OR Cyt>Cy THEN Res
8865       REM
8870       REM ******************************
8875       REM zero the high pressure arrays
8880       REM ******************************
8885       REM
8890       MAT P1= (0)
8895       MAT F1= (0)
8900       ENTER @File,1+Cyt;P1(*),F1(*)
8905       REM
8910       REM ************************************
8915       REM If the cycle chosen is the first one
8920       REM then the low pressure data is also
8925       REM used
8930       REM ************************************
8935       REM
8940       IF Cyt=1 THEN
8945         ENTER @File,1;Title$,Date$,Pen_id$,Lp,D,Hp,Temperature
8950         MAT P= (0)
8955         MAT F= (0)
8960         IF Lp THEN
8965           REDIM P(1:Lp),F(1:Lp)
8970           ENTER @File;P(*),F(*)
8975         END IF
8980         ENTER @File;Cy,Penl,Pend,Penv,Hgst,Cona,Scf,Epore,Espore,Eshgpore
8985         REDIM P(1:D),F(1:D)
8990         FOR I=Lp+1 TO D
8995           P(I)=P1(I-Lp)
9000           F(I)=F1(I-Lp)
9005         NEXT I
9010       ELSE
9015         ENTER @File,1;Title$,Date$,Pen_id$,Lp,D,Hp,Temperature
9020         D=D-Lp
9025         Hp=Hp-Lp
9030         Lp=0
9035         MAT P= (0)
9040         MAT F= (0)
9045         REDIM P(1:D),F(1:D)
9050         MAT P= P1
9055         MAT F= F1
9060       END IF
9065     END IF
9070     REM
9075     REM ************************************
9080     REM zero the arrays for analysis and set
9085     REM up to use the hard copy printer
9090     REM ************************************
9095     REM
9100     MAT Porev= (0)
9105     MAT A_= (0)
9110     MAT Deltv= (0)
9115     Printer=Hcopy
9120     REM
9125     REM ************************************
9130     REM Calculate the following values:
9135     REM
```

```
9140    REM Swt          The sample mass
9145    REM Density      The density of the mercury
9150    REM Pc0          The Po constant
9155    REM P0v0         The Po/Vo constant
9160    REM Apparent_d The apparent density
9165    REM              rounded off to 4 decimals
9170    REM Bulk_dens  The bulk density rounded
9175    REM              off to 4 decimals
9180    REM ************************************
9185    REM
9190    Swt=Espore-Epore
9195    Density=FNHg_density(Temperature)
9200    Pc0=Density*Penl*9.80665E-5
9205    P0v0=Pc0/(PI/4*Pend^2*Penl)
9210    Apparent_d=PROUND(Swt/(Penv-Scf*(F(Lp+1)-F(Hp))-(Eshgpore-Espore)/Density),-4)
9215    Bulk_dens=PROUND(Swt/(Penv-(Eshgpore-Espore)/Density),-4)
9220    REM
9225    REM ************************************
9230    REM If you want a hard copy of this data
9235    REM answer yes otherwise no for a softcopy
9240    REM If the softcopy is capable of 80
9245    REM column display you will see the same
9250    REM printout as the hardcopy otherwise a
9255    REM reduced display will be used
9260    REM ************************************
9265    REM
9270    Yes_no("Do you want a hard copy ?",Yes)
9275    OUTPUT 2 USING "#,B";255,75 ! CLEAR SCREEN
9280    IF Yes THEN
9285      Printer=Hcopy
9290      Copy=1
9295    ELSE
9300      Printer=Scopy
9305      REM
9310      REM ************************************
9315      REM The HP9826A computer has a 50 column
9320      REM dislay area while the 9816 and 9836
9325      REM screens are capable of 80 column
9330      REM display
9335      REM ************************************
9340      REM
9345      IF TRIM$(SYSTEM$("SYSTEM ID"))="9826A" THEN Copy=0
9350      IF TRIM$(SYSTEM$("SYSTEM ID"))="9836A" THEN Copy=1
9355      IF TRIM$(SYSTEM$("SYSTEM ID"))="9826" THEN Copy=1
9360    END IF
9365    REM
9370    REM ************************************
9375    REM Set the printer to one of choice and
9380    REM print the tables
9385    REM ************************************
9390    REM
9395    PRINTER IS Printer
9400    IF Printer=Hcopy THEN
9405      PRINT USING "K,K,50X,K";"For cycle ",Cyt,Date$
9410      PRINT USING "K,/";Title$
9415      PRINT USING C1;Swt,Pen_id$
9420      PRINT USING C2;Penv,Scf
9425      PRINT USING C3;Pend,Penl
9430      PRINT USING C4;Hgst,Cona
9435      PRINT USING C5;D,Hp,Lp
9440      PRINT USING C6;Temperature,179,Density
9445      PRINT USING C7;Bulk_dens
9450      PRINT USING C8;P(Hp),Apparent_d
9455    ELSE
9460      PRINT USING "K,K,27X,K";"For cycle ",Cyt,Date$
9465      PRINT USING "K,/";Title$
9470      PRINT USING Ca1;Swt,Pen_id$
9475      PRINT USING Ca2;Penv,Scf
9480      PRINT USING Ca3;Pend,Penl
9485      PRINT USING Ca4;Hgst,Cona
9490      PRINT USING Ca5;D,Hp,Lp
9495      PRINT USING Ca6;Temperature,179,Density
9500      PRINT USING C7;Bulk_dens
9505      PRINT USING C8;P(Hp),Apparent_d
9510    END IF
9515    REM
9520    REM ************************************
9525    REM Format statement for either 50 or 80
9530    REM column printing
9535    REM ************************************
```

```
9540      REM
9545  C1:IMAGE "Sample Mass",15X,2D.4D," g",6X,"Penetrometer Number",4X,10A
9550  C2:IMAGE "Penetrometer Volume",7X,2D.4D," cc",5X,"Stem Conversion Factor",X,DD.DDE,X,"cc/p
9555  C3:IMAGE "Penetrometer Stem Diameter",X,Z.DD,X,"cm",7X,"Penetrometer Length",4X,DD,X,"cm"
9560  C4:IMAGE "Mercury Surface Tension",4X,DDD,X,"dynes/cm",2X,"Contact Angle",10X,3D.D,X,"degr
9565  C5:IMAGE "Data Points=",3D,5X,"Highest Pressure Reading=",3D,5X,"Low Pressure Reading=",X,
9570  C6:IMAGE "Temperature =",3D.D,X,B,"C",10X,"Mercury density = ",2D.4D," g/cc"
9575  C7:IMAGE "The bulk density of the sample is ",Z.4D," g/cc"
9580  C8:IMAGE "The apparent density at ",3D.2D," MPa is ",Z.4D," g/cc",2/
9585  Ca1:IMAGE "Sample Mass",X,2D.4D,"g",2X,"Penetrometer ID",X,10A
9590  Ca2:IMAGE "Penetrometer Volume",X,2D.4D," cc",/,"Stem Conversion Factor",X,DD.DDE,X,"cc/pF'
9595  Ca3:IMAGE "Penetrometer Stem Diameter",X,Z.DD,X,"cm",/,"Penetrometer Length",X,DD,X,"cm"
9600  Ca4:IMAGE "Hg Surface Tension",X,DDD,X,"dynes/cm",/,"Contact Angle",X,3D.D,X,"deg"
9605  Ca5:IMAGE "Data Points= ",3D,2X,"Highest Pressure Point=",3D,/,"Low Pressure Points=",X,3D
9610  Ca6:IMAGE "Temperature =",3D.D,X,B,"C",/,"Mercury density = ",2D.4D," g/cc"
9615      REM
9620      REM ***********************************
9625      REM If the 80 column printing is used
9630      REM ***********************************
9635      REM
9640      IF Copy THEN
9645        PRINT USING Pst;"Cumulative Pore Volume"
9650        PRINT USING Pst2;"(cc)","(cc/g)"
9655        REM
9660        REM ***************************************
9665        REM Change the character 'u' (ASCII 117)
9670        REM to the greek letter mu if the hard
9675        REM copy option is specified
9680        REM ***************************************
9685        REM
9690        IF Printer=Hcopy THEN OUTPUT Hcopy USING "#,K";CHR$(27)&"&n117c34h34i34j50k46133m32N"
9695        PRINT USING Pst3
9700        REM
9705        REM ***************************************
9710        REM Reset character 117 back to default
9715        REM of 'u'
9720        REM ***************************************
9725        REM
9730        IF Printer=Hcopy THEN OUTPUT Hcopy USING "#,K";CHR$(27)&"&n117C"
9735        REM
9740        REM ***********************************
9745        REM If there is any low pressure data
9750        REM ***********************************
9755        REM
9760        IF Lp THEN PRINT "LOW PRESSURE INTRUSION DATA"
9765      END IF
9770  Pst:IMAGE "Pressure",3X,"Corrected",3X,"Pore Size",3X,"Intrusion",2X,"Cumulative",2X,22A
9775  Pst2:IMAGE X,"Reading",4X,"Pressure",4X,"Diameter",4X,"Reading",4X,"Intrusion",6X,4A,,6X,6
9780  Pst3:IMAGE 2X,"(MPa)",7X,"(MPa)",6X,"(um)",8X,"(pF)",9X,"(pF)",2/
9785      REM
9790      REM ***************************************
9795      REM Printout if 80 column display is used
9800      REM and calculate the following values
9805      REM
9810      REM Cumv(*)
9815      REM Pcorr(*)
9820      REM Pored(*)
9825      REM Porev(*)
9830      FOR I=1 TO D
9835        IF I=Hp+1 AND Copy THEN PRINT USING "/,K";"HIGH PRESSURE EXTRUSION DATA"
9840        IF I=Lp+1 AND Copy THEN PRINT USING "/,K";"HIGH PRESSURE INTRUSION DATA"
9845        IF NOT Lp THEN
9850          Cumv(I)=(F(Lp+1)-F(I))*Scf
9855        ELSE
9860          IF I<=Lp THEN
9865            Cumv(I)=(F(1)-F(I))*Scf
9870          ELSE
9875            Cumv(I)=(F(Lp+1)-F(I))*Scf+Cumv(Lp)
9880          END IF
9885        END IF
9890        Porev(I)=Cumv(I)/Swt
9895        IF I>Lp THEN
9900          Pcorr(I)=(Pc0-P0v0*Cumv(I))+P(I)
9905        ELSE
9910          Pcorr(I)=P(I)
9915        END IF
9920        Pored(I)=-.004*Hgst*COS(Cona)/Pcorr(I)
9925        IF I<=Lp AND Copy THEN
9930          PRINT USING Pore_size_data;P(I),Pcorr(I),Pored(I),F(I),F(1)-F(I),Cumv(I),Porev(I)
9935        END IF
```

```
9940        IF I>Lp AND Copy THEN
9945          PRINT USING Pore_size_data;P(I),Pcorr(I),Pored(I),F(I),F(Lp+1)-F(I),Cumv(I),Porev
9950        END IF
9955      NEXT I
9960  Pore_size_data:IMAGE M3D.3D,4X,M3D.3D,4X,M3D.3D,5X,M2D.2D,5X,M2D.2D,7X,MZ.DDD,5X,MZ.DDD
9965      REM
9970      REM ************************************
9975      REM If using the hard copy printer then
9980      REM change ASCII 175 (¯) to the greek
9985      REM letter sigma
9990      REM ************************************
9995      REM
10000     IF Printer=Hcopy THEN OUTPUT Hcopy USING "#,K";CHR$(27)&"&n175c62e34f16g8h4i8j16k3416
10005     REM
10010     REM ************************************
10015     REM Calculate the following for the second
10020     REM table
10025     REM
10030     REM Dav(*)
10035     REM Pav(*)
10040     REM Deltv(*)
10045     REM Pdv(*)
10050     REM Sumpdv(*)
10055     REM A_(*)
10060     REM ************************************
10065     REM
10070     FOR I=2 TO D
10075       Dav(I)=(Pored(I)+Pored(I-1))/2
10080       Pav(I)=(Pcorr(I)+Pcorr(I-1))/2
10085       Deltv(I)=Porev(I)-Porev(I-1)
10090       Pdv(I)=Pav(I)*Deltv(I)
10095       Sumpdv(I)=Sumpdv(I-1)+Pdv(I)
10100       A_(I)=.0225/6.895E-3*Sumpdv(I)
10105     NEXT I
10106     REM
10107     REM ************************************
10108     REM If a 80 column display is possible
10109     REM ************************************
10110     REM
10112     IF Copy THEN
10115       REM
10120       REM ************************************
10125       REM Print top of form and set up
10130       REM overlining of the two characters
10135       REM 'P' and 'D' if the printer is hard
10140       REM copy otherwise print 2 linefeeds and
10145       REM forget about the fancy characters
10150       REM ************************************
10155       REM
10160       IF Printer=Hcopy THEN PRINT USING "#,@"
10165       IF Printer=Scopy THEN PRINT USING "2/"
10170       Ol$=CHR$(27)&"&dP"
10175       Nol$=CHR$(27)&"&dA"
10180       IF Printer=Scopy THEN
10185         Pp$="P"
10190         Dd$="D"
10195       ELSE
10200         Pp$=Ol$&"P"&Nol$
10205         Dd$=Ol$&"D"&Nol$
10210       END IF
10215       REM
10220       REM ********************************
10225       REM Print the first line of the table
10230       REM headings
10235       REM ********************************
10240       REM
10245       PRINT USING Table_titles;Dd$,Pp$,Pp$,175,Pp$&"dV","Cumulative Area"
10250       REM
10255       REM ************************************
10260       REM Set the ASCII 117 (u) to the greek
10265       REM letter mu on the hardcopy printer
10270       REM ************************************
10275       REM
10280       IF Printer=Hcopy THEN OUTPUT Hcopy USING "#,K";CHR$(27)&"&n117c34h34i34j50k46l33m32
10285       REM
10290       REM ************************************
10295       REM Print the rest of the table headings
10300       REM ************************************
10305       REM
10310       PRINT USING Table_titles_2;"(MPa)","(cc/g)","(um)","(MPa)","(cc/g)","(m^2/g)","per
```

```
10315     IF Lp THEN PRINT "LOW PRESSURE INTRUSION DATA"
10320 Table_titles:IMAGE 4X,"P",6X,"V",7X,K,7X,K,6X,"dV",7X,K,"dV",7X,B,K,6X,K
10325 Table_titles_2:IMAGE XX,5A,XX,6A,XX,4A,4X,5A,2X,6A,22X,7A,5X,K,/
10330     IF NOT Lp THEN PRINT USING "/,K";"HIGH PRESSURE INTRUSION DATA"
10335     PRINT USING P_ts;P(1)
10340   END IF
10345   IF Printer=Hcopy THEN
10350     REM
10355     REM ************************************
10360     REM Reset ASCII 175 and 117 back to the
10365     REM default of '£' and 'u'
10370     REM ************************************
10375     REM
10380     OUTPUT Hcopy USING "#,K";CHR$(27)&"&n175C"
10385     OUTPUT Hcopy USING "#,K";CHR$(27)&"&n117C"
10390   END IF
10395   REM
10400   REM ************************************
10405   REM Print the main body of the second
10410   REM table if it is an 80 column printer
10415   REM and calculate Percenta(*)
10420   REM ************************************
10425   REM
10430   FOR I=2 TO D
10435     IF I=Lp+1 AND Copy THEN
10440       PRINT USING "/,K";"HIGH PRESSURE INTRUSION DATA"
10445     END IF
10450     IF I=Hp+1 AND Copy THEN PRINT USING "/,K";"HIGH PRESSURE EXTRUSION DATA"
10455     Percenta(I)=A_(I)/A_(Hp)*100
10460     IF Copy THEN
10465       PRINT USING P_ts;P(I),Porev(I),Dav(I),Pav(I),Deltv(I),Pdv(I),Sumpdv(I),A_(I),Percen
10470     END IF
10475   NEXT I
10480 P_ts:IMAGE 3D.3D,X,MZ.3D,X,3D.3D,X,3D.3D,X,MZ.3D,2X,MZ.DDE,X,MZ.DDE,X,MZ.DDE,2X,3D.3D
10485   REM
10490   REM ****************************************
10495   REM Print top-of-form if hard copy printer
10500   REM ****************************************
10505   REM
10510   IF Printer=Hcopy THEN PRINT USING "#,@"
10515   PRINTER IS Scopy
10520   REM
10525   REM ************************************
10530   REM The first curve is plotted
10535   REM
10540   REM The values plotted are:
10545   REM          Pcorr(*) vs Porev(*)
10550   REM The area is also calculated from the
10555   REM straight line portion of the curve
10560   REM using a least-squares approach
10565   REM ****************************************
10570   REM
10575   Yes_no("Do you want to look at PRESSURE vs % AREA ?",Yes)
10580   IF Yes THEN CALL Plot_p_vs_a1(Pcorr(*),Porev(*),A_(*),Cutoff,Hp,Lp,D)
10585   REM
10590   REM ****************************************
10595   REM The second curve is plotted
10600   REM
10605   REM the values plotted are:
10610   REM       LOG(Pored(*)) vs Porev(*)
10615   REM
10620   REM Porev(*) is calculated as per cent
10625   REM ****************************************
10630   REM
10635 Plot_d_vs_v:Yes_no("Look at PORE DIAMETER vs % PORE VOLUME ?",Yes)
10640   IF NOT Yes THEN Plot_d_vs_deltv
10645   GOSUB Subplot
10650   REM
10655   REM **********
10660   REM Label axes
10665   REM **********
10670   REM
10675 W1:MOVE 3,-8
10680   LABEL USING "K";"Pore diameter (um)"
10685   LDIR 90
10690   MOVE -.5,50
10695   LABEL USING "K";"Per Cent Pore Volume"
10700   LDIR 0
10705   REM
10710   REM ************************************
```

```
10715   REM Find the maximum value of Porev(*)
10720   REM ********************************
10725   REM
10730   Maximum=MAX(Porev(*))
10735   REM
10740   REM ************************************
10745   REM Plot the points on plotting device and
10750   REM distinguish between the three type of
10755   REM points
10760   REM ************************************
10765   REM
10770   FOR I=1 TO D
10775     MOVE LGT(Pored(I)*1000),Porev(I)/Maximum*100
10780     IF I>Hp THEN LABEL USING "K";"+"
10785     IF (I<=Hp) AND (I>Lp) THEN LABEL USING "K";"*"
10790     IF I<=Lp THEN LABEL USING "K";"#"
10795   NEXT I
10800   REM
10805   REM ************************************
10810   REM Label what is 100 per cent of scale in
10815   REM real terms
10820   REM ************************************
10825   REM
10830   MOVE 3,105
10835   LABEL USING "K,MZ.3D,K";"100 per cent is ",Maximum," cc/g"
10840   REM
10845   REM ************************************
10850   REM If hardcopy plotter then clean up and
10855   REM then exit otherwise pause until the
10860   REM operator is ready to move on
10865   REM ************************************
10870   REM
10875   IF NOT Hplotter THEN CALL Pauser
10880   IF Hplotter THEN Pxxx
10885   REM
10890   REM ************************************
10895   REM If this was not a hardcopy plot then
10900   REM you can get one
10905   REM ************************************
10910   REM
10915   Yes_no("Do you want a hard copy ?",Yes)
10920   IF NOT Yes THEN Plot_d_vs_delty
10925 W1a:Yes_no("Do you want to use the plotter ?",Yes)
10930   IF Yes THEN
10935     REM
10940     REM *********************************
10945     REM Set up hardcopy plotter and replot
10950     REM curve
10955     REM *********************************
10960     REM
10965     Branch=1
10970     GOSUB Hplotter
10975     GOTO W1
10980   END IF
10985   Yes_no("Do you want a thermal copy ?",Yes)
10990   IF Yes THEN
10995     REM
11000     REM *********************************
11005     REM Change character 175 '£' to the
11010     REM greek letter mu
11015     REM *********************************
11020     REM
11025     OUTPUT Hcopy USING "#,K";CHR$(27)&"&n175c34h34i34j50k46133m32N"  !MU USING £
11030     REM
11035     REM ************************************
11040     REM Print the title of the graph then
11045     REM reset the character 175 to default
11050     REM Print the 100 per cent value and its
11055     REM equivalent in real terms
11060     REM Dump the soft graphics on to the
11065     REM appropriate printing device
11070     REM print a line feed to provide easy
11075     REM viewing
11080     REM ************************************
11085     REM
11090     OUTPUT Hcopy USING "K";"Pore Diameter (£m) vs Per Cent Pore Volume"
11095     OUTPUT Hcopy USING "#,K";CHR$(27)&"&n175C"
11100     OUTPUT Hcopy USING "K,MZ.3D,K";"100 per cent is ",Maximum," cc/g"
11105     DUMP GRAPHICS
11110     OUTPUT Hcopy USING "/"
```

```
11115    END IF
11120    REM
11125    REM ***********************************
11130    REM The third curve is plotted
11135    REM
11140    REM The values plotted are:
11145    REM          LOG(Dav(*)) vs Deltv(*)
11150    REM
11155    REM Deltv(*) is converted to per cent
11160    REM ***********************************
11165    REM
11170  Plot_d_vs_deltv:Yes_no("Look at MEAN PORE DIA. vs % DELTA PORE VOLUME ?",Yes)
11175    IF NOT Yes THEN Plot_d_vs_area
11180    REM
11185    REM *******************************
11190    REM Set up the graph for plotting
11195    REM *******************************
11200    REM
11205    GOSUB Subplot
11210    REM
11215    REM ***************
11220    REM Label the axes
11225    REM ***************
11230    REM
11235  W2:MOVE 3,-8
11240    LABEL USING "K";"Mean Pore diameter (um)"
11245    LDIR 90
11250    MOVE -.5,50
11255    LABEL USING "K";"Per Cent Delta Pore Volume"
11260    LDIR 0
11265    REM
11270    REM ***********************************
11275    REM Find the maximum value of Deltv(*)
11280    REM ***********************************
11285    REM
11290    Maximum=MAX(Deltv(*))
11295    REM
11300    REM ***************************************
11305    REM Plot the data points up to the highest
11310    REM pressure point
11315    REM ***************************************
11320    REM
11325    FOR I=2 TO Hp
11330      MOVE LGT(Dav(I)*1000),Deltv(I)/Maximum*100
11335      IF I>Lp THEN LABEL USING "K";"*"
11340      IF I<=Lp THEN LABEL USING "K";"#"
11345    NEXT I
11350    REM
11355    REM ***********************************
11360    REM Move to the start of the points and
11365    REM 'connect the dots'
11370    REM ***********************************
11375    REM
11380    MOVE LGT(Dav(2)*1000),Deltv(2)/Maximum*100
11385    FOR I=2 TO Hp
11390      DRAW LGT(Dav(I)*1000),Deltv(I)/Maximum*100
11395    NEXT I
11400    MOVE 3,105
11405    REM
11410    REM ***************************************
11415    REM Label what 100 per cent of scale is in
11420    REM real terms
11425    REM ***************************************
11430    REM
11435    LABEL USING "K,MZ.3D,K";"100 per cent is ",Maximum," cc/g"
11440    REM
11445    REM ***********************************
11450    REM If a soft copy plot then wait until
11455    REM the operator is ready to move on
11460    REM otherwise clear up the plotter
11465    REM ***********************************
11470    REM
11475    IF NOT Hplotter THEN CALL Pauser
11480    IF Hplotter THEN Pxxx
11485    REM
11490    REM ***********************************
11495    REM You are given to opertunity to get a
11500    REM hardcopy of the graph either on the
11505    REM plotter or a dump of the softcopy to
11510    REM the printer
```

```
11515   REM ************************************
11520   REM
11525   Yes_no("Do you want a hard copy ?",Yes)
11530   IF NOT Yes THEN Plot_d_vs_area
11535 W2a:Yes_no("Do you want to use the plotter ?",Yes)
11540   IF Yes THEN
11545     REM
11550     REM ***********************************
11555     REM Set up hardcopy plotter and replot
11560     REM curve
11565     REM ***********************************
11570     REM
11575     Branch=2
11580     GOSUB Hplotter
11585     GOTO W2
11590   END IF
11595   Yes_no("Do you want a thermal copy ?",Yes)
11600   IF NOT Yes THEN Plot_d_vs_area
11605   REM
11610   REM *********************************
11615   REM Change character 175 'ß' to the
11620   REM greek letter mu
11625   REM *********************************
11630   REM
11635   OUTPUT Hcopy USING "#,K";CHR$(27)&"&n175c34h34i34j50k46133m32N"
11640   REM
11645   REM ************************************
11650   REM Print the title of the graph then
11655   REM reset the character 175 to default
11660   REM Print the 100 per cent value and its
11665   REM equivalent in real terms
11670   REM Dump the soft graphics on to the
11675   REM appropriate printing device
11680   REM print a line feed to provide easy
11685   REM viewing
11690   REM ************************************
11695   REM
11700   OUTPUT Hcopy USING "K";"Mean Pore Diameter (ßm) vs Per Cent Delta Pore Volume"
11705   OUTPUT Hcopy USING "#,K";CHR$(27)&"&n175C"
11710   OUTPUT Hcopy USING "K,MZ.3D,K,";"100 per cent is ",Maximum," cc/g"
11715   DUMP GRAPHICS
11720   OUTPUT Hcopy USING "/"
11725   REM
11730   REM *********************************
11735   REM The fourth curve is plotted
11740   REM
11745   REM The values plotted are:
11750   REM         LOG(Dav(*)) vs Percenta(*)
11755   REM ************************************
11760   REM
11765 Plot_d_vs_area:Yes_no("Look at MEAN PORE DIAMETER vs % PORE AREA ?",Yes)
11770   IF NOT Yes THEN Exit
11775   REM
11780   REM ******************************
11785   REM Set up the graph for plotting
11790   REM ******************************
11795   REM
11800   GOSUB Subplot
11805   REM
11810   REM **************
11815   REM Label the axes
11820   REM **************
11825   REM
11830 W3:MOVE 3,-8
11835   LABEL USING "K";"Mean Pore diameter (um)"
11840   LDIR 90
11845   MOVE -.5,50
11850   LABEL USING "K";"Per Cent Pore Area"
11855   LDIR 0
11860   REM
11865   REM ***************************************
11870   REM Plot the data points up to the highest
11875   REM pressure point
11880   REM ***************************************
11885   REM
11890   FOR I=2 TO Hp
11895     MOVE LGT(Dav(I)*1000),Percenta(I)
11900     IF I<=Lp THEN LABEL USING "K";"#"
11905     IF I>Lp THEN LABEL USING "K";"*"
11910   NEXT I
```

```
11915    REM
11920    REM ****************************************
11925    REM Label what 100 per cent of scale is in
11930    REM real terms.
11935    REM ****************************************
11940    REM
11945    MOVE 3,105
11950    LABEL USING "K,MZ.DDE,K";"100 per cent is ",A_(Hp)," m^2/g"
11955    REM
11960    REM ************************************
11965    REM If hardcopy then clean up the plotter
11970    REM and then goto W3a otherwise wait for
11975    REM the operator to move on.
11980    REM ************************************
11985    REM
11990    IF NOT Hplotter THEN CALL Pauser
11995    IF Hplotter THEN Pxxx
12000    REM
12005    REM ************************************
12010    REM The choice of hard copy of the graph
12015    REM ************************************
12020    REM
12025    Yes_no("Do you want a hard copy ?",Yes)
12030    IF NOT Yes THEN Exit
12035 W3a:Yes_no("Do you want to use the plotter ?",Yes)
12040    IF Yes THEN
12045      REM
12050      REM ************************************
12055      REM Set up the hard plotter and draw the
12060      REM axes for the third semi-log plot
12065      REM ************************************
12070      REM
12075      Branch=3
12080      GOSUB Hplotter
12085      GOTO W3
12090    END IF
12095    REM
12100    REM ****************************************
12105    REM If a thermal copy is desired then:
12110    REM
12115    REM Character 175 is changed to the greek
12120    REM letter mu.  The title of the graph is
12125    REM printed and then the character 175 is
12130    REM reset to default.  The 100 per cent of
12135    REM scale is printed and then the softcopy
12140    REM of the plot is dumped to the printer
12145    REM and a linefeed is also outputted after
12150    REM for ease of viewing.
12155    REM ****************************************
12160    REM
12165    Yes_no("Do you want a thermal copy ?",Yes)
12170    IF NOT Yes THEN Exit
12175    OUTPUT Hcopy USING "#,K";CHR$(27)&"&n175c34h34i34j50k46133m32N"    !MU USING £
12180    OUTPUT Hcopy USING "K";"Mean Pore Diameter (£m) vs Per Cent Pore Area"
12185    OUTPUT Hcopy USING "#,K";CHR$(27)&"&n175C"
12190    OUTPUT Hcopy USING "K,MZ.DDE,K";"100 per cent is ",A_(Hp)," m^2/g"
12195    DUMP GRAPHICS
12200    OUTPUT Hcopy USING "/"
12205    REM
12210    REM ************************************
12215    REM The softcopy graphics are turn off and
12220    REM cleared.  The alpha mode is enabled
12225    REM and the printer is set to softcopy.
12230    REM ************************************
12235    REM
12240 Exit:GRAPHICS OFF
12245    ALPHA ON
12250    GCLEAR
12255    PRINTER IS Scopy
12260    REM
12265    REM ************************************
12270    REM If the data was not manually input the
12275    REM operator will have the choice of
12280    REM viewing another cycle of this data set
12285    REM or looking at other data sets
12290    REM otherwise the program will exit
12295    REM ************************************
12300    REM
12305    IF NOT Man THEN
12310      Yes_no("Do you want to look at more cycles of this set ?",Yes)
```

```
12315     IF Yes THEN Res
12320     Yes_no("Do you want to look at other data sets ?",Yes)
12325     ASSIGN @File TO *
12330     IF Yes THEN
12335       Filedata(@File)
12340       GOTO Res
12345     END IF
12350   END IF
12355   OUTPUT 2 USING "#,B";255,75 ! Clear screen
12360   SUBEXIT
12365   REM
12370   REM ****************************************
12375   REM Plot semi-log scale axes and labels on
12380   REM the softcopy graphics
12385   REM ****************************************
12390   REM
12395 Subplot:DEG
12400   Hplotter=0      ! softcopy graphics
12405   OUTPUT 2 USING "#,B";255,75 ! Clear screen
12410   Ymin=0
12415   Ymax=100
12420   Log_interval=6
12425   Xmin=.001
12430   Xmax=1000
12435   REM
12440   REM ****************************************
12445   REM Initialize the softcopy graphics and
12450   REM define the plotting device. Enable the
12455   REM graphics mode and disable the alpha
12460   REM set the plotting limits to be above
12465   REM the label area of the special function
12470   REM keys
12475   REM ****************************************
12480   REM
12485   GINIT
12490   PLOTTER IS Splot,Splot$
12495   GRAPHICS ON
12500   ALPHA OFF
12505   VIEWPORT 10,105,10,95
12510   REM
12515   REM ********************************
12520   REM This is common to the subroutines
12525   REM       Subplot and Logrithmic
12530   REM
12535   REM Scale the plotting surface and draw
12540   REM the axes and then label them
12545   REM NOTE: The x-axis is drawn explicitly
12550   REM       not by the axes command
12555   REM ************************************
12560   REM
12565 Logrithmic:WINDOW Log_interval,Xmin,Ymin-10,Ymax+10
12570   CLIP Log_interval,Xmin,Ymin,Ymax
12575   AXES 0,5,0,Ymin,2,2,2
12580   CLIP OFF
12585   MOVE Log_interval,0+Ymin
12590   DRAW Log_interval,2+Ymin
12595   FOR Decade=Log_interval-1 TO 0 STEP -1
12600     FOR Interval=9 TO 1 STEP -1
12605       MOVE Decade+LGT(Interval),0+Ymin
12610       DRAW Decade+LGT(Interval),Ymin+1
12615     NEXT Interval
12620     MOVE Decade,0+Ymin
12625     DRAW Decade,Ymin+2
12630   NEXT Decade
12635   REM
12640   REM ********************************
12645   REM Center the labels around the chosen
12650   REM x and y coordinates horizontally
12655   REM ********************************
12660   REM
12665 Log_labels:LORG 5
12670   LDIR 0
12675   REM
12680   REM ********************************
12685   REM Assign the labels of the x-axis
12690   REM ********************************
12695   REM
12700   Log_$(1)="0.001"
12705   Log_$(2)="0.01"
12710   Log_$(3)="0.1"
```

```
12715   Log_$(4)="1"
12720   Log_$(5)="10"
12725   Log_$(6)="100"
12730   Log_$(7)="1000"
12735   REM
12740   REM ***************************************
12745   REM Choose appropriate character size and
12750   REM label the x-axis
12755   REM ***************************************
12760   REM
12765   CSIZE 3,.6
12770   FOR Decade=0 TO Log_interval
12775     MOVE Decade,-4+Ymin
12780     LABEL Log_$(Decade+1)
12785   NEXT Decade
12790   REM
12795   REM ***************************************
12800   REM Label the y-axis centered around the
12805   REM x and y coordinates horizontally using
12810   REM the appropriate character size and
12815   REM rounded to no decimal place
12820   REM ***************************************
12825   REM
12830 Lin_labels:LORG 5
12835   LDIR 0
12840   CSIZE 3,.6
12845   FOR Y_axis=0 TO Ymax STEP 10
12850     MOVE -.2,Y_axis
12855     LABEL PROUND(Y_axis,0)
12860   NEXT Y_axis
12865   REM
12870   REM **********************
12875   REM End of subroutines
12880   REM Subplot and Logrithmic
12885   REM **********************
12890   REM
12895   RETURN
12900   REM
12905   REM ***************************************
12910   REM Clean up the hardcopy plotter by:
12915   REM
12920   REM 1. Lifting up the pen
12925   REM 2. Turning off SFK interupts
12930   REM 3. Returning the pen to its stall
12935   REM 4. Initializing the plotter
12940   REM 5. Output the original hardclip limits
12945   REM 6. Setting the printer to softcopy
12950   REM 7. Defining the plotter as softcopy
12955   REM 8. Returning to the appropriate spot
12960   REM    in the program ie. Ask if the
12965   REM    operator wants to use the hardcopy
12970   REM    plotter to draw the curve again
12975   REM ***************************************
12980   REM
12985 Pxxx:PENUP
12990   OFF KEY
12995   PEN 0
13000   PRINT "IN;"
13005   PRINT USING Chng;"IP",P1x,",",P1y,",",P2x,",",P2y,";"
13010   PRINTER IS Scopy
13015   PLOTTER IS Splot,Splot$
13020   Hplotter=0
13025 Chng:IMAGE 2A,4(5D,A)
13030   ON Branch GOTO W1a,W2a,W3a
13035   REM
13040   REM ***************************************
13045   REM Set up the hardcopy plotter for use by
13050   REM
13055   REM 1. Letting the operator set the limits
13060   REM    of the axes
13065   REM    NOTE: The computer will allow extra
13070   REM          space for labels
13075   REM 2. Define the printer the same device
13080   REM    as the plotter to allow ease of
13085   REM    passing commands
13090   REM 3. Ask the plotter to send the current
13095   REM    hard clip limits
13100   REM 4. Calculate and then sent the new
13105   REM    hard clip limits to the plotter
13110   REM 5. Define the hardcopy plotter
```

```
13115   REM 6. Set the pen speed to 5 cm/s
13120   REM 7. Set the linetype to a smooth line
13125   REM 8. Set the label origin, direction and
13130   REM    character size
13135   REM 9. Set the special function key #4 to
13140   REM    interupt to allow for a clean
13145   REM    shutdown of the plotter device
13150   REM ****************************************
13155   REM
13160 Hplotter:Yes_no("Is the paper loaded & P1 and P2 set ?",Yes)
13165   IF NOT Yes THEN Hplotter
13170   PRINTER IS Hplot
13175   PRINT "OP;"
13180   ENTER Hplot;P1x,P1y,P2x,P2y
13185   Xscale=(P2x-P1x)*Xtick/Xmax
13190   Yscale=(P2y-P1y)*Ytick/Ymax
13195   PRINT USING Chng;"IP",P1x-Xscale,",",P1y-Yscale,",",P2x+Xscale,",",P2y+Yscale,";"
13200   PLOTTER IS Hplot,Hplot$
13205   PRINT "VS5;"
13210   LINE TYPE 1
13215   DEG
13220   LORG 5
13225   CSIZE 3,.6
13230   Hplotter=1
13235   ON KEY 4 LABEL "ABORT" GOTO Pxxx
13240   REM
13245   REM ********************
13250   REM Go and plot the axes
13255   REM ********************
13260   REM
13265   GOSUB Logrithmic
13270   REM
13275   REM ********************************
13280   REM End of the subroutine Hplotter
13285   REM ********************************
13290   REM
13295   RETURN
13300   REM
13305   REM ***************************
13310   REM End of subprogram Analyse
13315   REM ***************************
13320   REM
13325 SUBEND
13330 SUB Filedata(@File)
13335   REM
13340   REM ****************************************
13345   REM Subprogram Filedata
13350   REM
13355   REM Gets data stored by this program for
13360   REM analysis
13365   REM
13370   REM @File is returned as the I/O path to
13375   REM       the datafile
13380   REM
13385   REM The common declarations are the same
13390   REM as in the main program
13395   REM
13400   REM          Local variables
13405   REM
13410   REM Character strings
13415   REM
13420   REM File$[10] The name of the data file
13425   REM
13430   REM Integer Variables
13435   REM
13440   REM Outcome    The return variable of the
13445   REM            ASSIGN statement
13450   REM Yes        Either to 1 (true) else set
13455   REM            to 0 (false)
13460   REM ****************************************
13465   REM
13470   COM /Constants/ INTEGER Hcopy,Scopy,Splot,Hplot,Datalogger
13475   COM /Constants/ Splot$,Hplot$,Store$,Prog$,Security$
13480   COM /Analyse/ Temperature,Penl,Pend,Penv,Hgst,Cona,Scf
13485   COM /Analyse/ INTEGER D,Hp,Lp,Cy
13490   COM /Analyse/ Date$,Title$,Swt,Pen_id$,P(*),F(*)
13495   COM /Analyse/ Epore,Espore,Eshgpore
13500   INTEGER Outcome,Yes
13505   DIM File$[10]
13510   REM
```

```
13515    REM ************************************
13520    REM Set the printer for softcopy and
13525    REM output the current file name to the
13530    REM operator to modify and input to the
13535    REM computer
13540    REM ************************************
13545    REM
13550    PRINTER IS Scopy
13555 Start:OUTPUT 2;File$;
13560    LINPUT "What is the file name ?",File$
13565    REM
13570    REM ****************************************
13575    REM You may now insert the appropriate
13580    REM data media in the stroage device
13585    REM specfied by Store$
13590    REM
13595    REM If there are any problems then the
13600    REM following cases will hopefully cope
13605    REM with them.  They are identified by the
13610    REM return variable Outcome on the assign
13615    REM statement
13620    REM
13625    REM CASE 0
13630    REM
13635    REM If the file exists and is the correct
13640    REM type (BDAT) then the computer will use
13645    REM it to get the necessary data for
13650    REM analysis
13655    REM
13660    REM CASE 56
13665    REM
13670    REM If the file doesn't exist on this
13675    REM media
13680    REM
13685    REM CASE 58
13690    REM
13695    REM If the file exists and is a program
13700    REM type file or an ASCII type file then
13705    REM you must choose another name
13710    REM
13715    REM case 53
13720    REM
13725    REM If the filename is too long (more than
13730    REM 10 characters) then you will have to
13735    REM input another file name
13740    REM
13745    REM CASE 80
13750    REM
13755    REM If the media isn't installed correctly
13760    REM or if the door is open then correct
13765    REM the problem. Then you will have to
13770    REM input the file name again.
13775    REM
13780    REM CASE 62
13785    REM
13790    REM If the data file exists but is not one
13795    REM created by this program then you will
13800    REM have to input another file name
13805    REM This is done by the security code and
13810    REM is the way the program distinguishes
13815    REM between ASCII and BDAT data files
13820    REM
13825    REM CASE ELSE
13830    REM
13835    REM If there is a fatal error then the
13840    REM the program will stop and you will
13845    REM have to restart the process again.
13850    REM ****************************************
13855    REM
13860 Cord1:Yes_no("Is the correct data disc installed ?",Yes)
13865   IF NOT Yes THEN Cord1
13870   ASSIGN @File TO File$&Security$&Store$;RETURN Outcome
13875   SELECT Outcome
13880   CASE 0
13885     PRINT "File "&File$&Store$&" is ready to be used"
13890     ENTER @File,1;Title$,Date$,Pen_id$,Lp,D,Hp,Temperature
13895     IF Lp THEN
13900       REDIM P(1:Lp),F(1:Lp)
13905       ENTER @File;P(*),F(*)
13910       REDIM P(1:D),F(1:D)
```

```
13915     END IF
13920     ENTER @File;Cy,Penl,Pend,Penv,Hgst,Cona,Scf
13925   CASE 58
13930     PRINT File$&Store$&" is not a data file"
13935     GOTO Start
13940   CASE 53
13945     PRINT File$&" is too long a name (MAX 10 characters)"
13950     GOTO Start
13955   CASE 56
13960     PRINT File$&" does not exist on this media. Try again."
13965     GOTO Start
13970   CASE 62
13975     PRINT File$&Store$&" is not the correct type of data file for this program.  Try ag
13980   CASE 80
13985     PRINT "The door is open or media is not installed"
13990     GOTO Start
13995   CASE ELSE
14000     PRINT "FATAL ERROR"
14005     PRINT Outcome;" is the error number"
14010     STOP
14015   END SELECT
14020   REM
14025   REM ****************************************
14030   REM End of subprogram filedata
14035   REM ****************************************
14040   REM
14045 SUBEND
14050 SUB Mandata
14055   REM
14060   REM ****************************************
14065   REM Subprogram Mandata
14070   REM
14075   REM To manually input poresimeter data for
14080   REM analysis and storage
14085   REM
14090   REM The common declarations are the same
14095   REM as in the main program
14100   REM
14105   REM         LOCAL VARIABLES
14110   REM
14115   REM REAL VARIABLES
14120   REM
14125   REM Penhg      The mass of the penetrometer
14130   REM            filled with just mercury (g)
14135   REM Bulk_dens  The bulk density of the
14140   REM            sample
14145   REM Density    The density of mercury at a
14150   REM            given temperature (°C)
14155   REM Apparent_d The density of the sample
14160   REM            at the given pressure
14165   REM
14170   REM INTEGER VARIABLES
14175   REM
14180   REM Yes    For yes/no type questions if the
14185   REM        returned value is 1 then yes if
14190   REM        returned 0 then no
14195   REM I      Counter for FOR..NEXT loops
14200   REM Flag1  Used with Flag2 to identify
14205   REM        which section is being corrected
14210   REM
14215   REM              Flag1  Flag2      Section
14220   REM                0      0     Low pressure
14225   REM                1      0     high pressure
14230   REM                             intrusion
14235   REM                1      1     high pressure
14240   REM                             extrusion
14245   REM Flag2 See Flag1
14250   REM Check  Used for identifing which point
14255   REM        is incorrect
14260   REM ****************************************
14265   REM
14270   COM /Constants/ INTEGER Hcopy,Scopy,Splot,Hplot,Datalogger
14275   COM /Constants/ Splot$,Hplot$,Store$,Prog$,Security$
14280   COM /Analyse/ Temperature,Penl,Pend,Penv,Hgst,Cona,Scf
14285   COM /Analyse/ INTEGER D,Hp,Lp,Cy
14290   COM /Analyse/ Date$,Title$,Swt,Pen_id$,P(*),F(*)
14295   COM /Analyse/ Epore,Espore,Eshgpore
14300   REAL Penhg,Bulk_dens,Density,Apparent_d
14305   INTEGER Yes,I,Flag1,Flag2,Check
14310   REM
```

```
14315    REM ****************************************
14320    REM Set the printer to softcopy
14325    REM Output the current value for the date
14330    REM to the operator for modification and
14335    REM input to the computer
14340    REM ****************************************
14345    REM
14350    PRINTER IS Scopy
14355 Start:OUTPUT 2;Date$;
14360    LINPUT "What is the date of the test ?",Date$
14365    Date$=TRIM$(Date$)
14370    IF LEN(Date$)=0 THEN Date$="No Date Given"
14375    PRINT USING "@,35X,K";Date$
14380    REM
14385    REM ***********************************
14390    REM Output the existing title and then
14395    REM allow the operator to modify and
14400    REM then input to the computer
14405    REM ***********************************
14410    REM
14415    OUTPUT 2;Title$;
14420    LINPUT "What is the title of the data ?",Title$
14425    Title$=TRIM$(Title$)
14430    IF LEN(Title$)=0 THEN Title$="No title given"
14435    PRINT USING "K,/";Title$
14440    REM
14445    REM****************************************
14450    REM Input the temperature the mercury was
14455    REM for the experiment then calculate the
14460    REM density of mercury using it
14465    REM ****************************************
14470    REM
14475    INPUT "What is the room temperature (°C) ?",Temperature
14480    PRINT "The room temperature is";Temperature;"deg C"
14485    PRINT "The density of mercury is";FNHg_density(Temperature);"g/cc"
14490    REM
14495    REM ***********************************
14500    REM Input the mercury surface tension
14505    REM If unknown use 485 dynes/cm
14510    REM ***********************************
14515    REM
14520    INPUT "What is the mercury surface tension (dyne/cm) ?",Hgst
14525    PRINT "The mercury surface tension is";Hgst;"dynes/cm"
14530    REM
14535    REM ****************************************
14540    REM Input the contact angle of the mercury
14545    REM and the solid.  If unknown use 130°
14550    REM ****************************************
14555    REM
14560    INPUT "What is the contact angle (deg) ?",Cona
14565    PRINT "The contact angle is";Cona;"deg"
14570    REM
14575    REM ****************************************
14580    REM Input the empty penetrometer mass and
14585    REM the mass of the penetrometer and
14590    REM sample to calculate the sample mass
14595    REM
14600    REM Input the mass of the penetrometer,
14605    REM sample and mercury to calculate the
14610    REM apparent bulk density
14615    REM ****************************************
14620    REM
14625    INPUT "What is the mass of the empty penetrometer ?",Epore
14630    PRINT "The mass of the empty penetrometer";Epore;"g"
14635    INPUT "What is the mass of the penetrometer and sample ?",Espore
14640    PRINT "The mass of the penetrometer and sample";Espore;"g"
14645    INPUT "What is the mass of the penetrometer, sample & Hg ?",Eshgpore
14650    PRINT "The mass of the penetrometer, sample & Hg";Eshgpore;"g"
14655    Swt=Espore-Epore
14660    PRINT "The mass of the coal =";Swt;"g"
14665    REM
14670    REM ****************************************
14675    REM Output the current penetrometer
14680    REM identifier and allow the operator to
14685    REM modify and then input to the computer
14690    REM ****************************************
14695    REM
14700    OUTPUT 2;Pen_id$;
14705    LINPUT "What is the penetrometer id ?",Pen_id$
14710    Pen_id$=TRIM$(Pen_id$)
```

```
14715   IF LEN(Pen_id$)=0 THEN Pen_id$="Unknown"
14720   PRINT "The penetrometer id = ";Pen_id$
14725   REM
14730   REM ****************************************
14735   REM Input the stem correction factor to be
14740   REM used for the penetrometer during the
14745   REM experiment
14750   REM ****************************************
14755   REM
14760   INPUT "What is the STEM CORRECTION FACTOR (cc/pF) ?",Scf
14765   PRINT "Stem Correction Factor";Scf;"cc/pF"
14770   REM
14775   REM ************************************
14780   REM Input the penetrometer diameter (cm)
14785   REM that is used during the experiment
14790   REM ************************************
14795   REM
14800   INPUT "What is the PENETROMETER DIAMETER (cm) ?",Pend
14805   PRINT "Penetrometer Diameter";Pend;"cm"
14810   REM
14815   REM ****************************************
14820   REM The operator is allow two choices:
14825   REM
14830   REM  1) Calculate the penetrometer volume
14835   REM     by inputting the mass of the pene-
14840   REM     trometer filled with just mercury
14845   REM
14850   REM  2) Input the calculated penetrometer
14855   REM     volume
14860   REM ****************************************
14865   REM
14870   Yes_no("Calculate PENETROMETER VOLUME ?",Yes)
14875   IF Yes THEN
14880     INPUT "What is the MASS OF PENETROMETER+HG ?",Penhg
14885     Penv=(Penhg-Epore)/FNHg_density(Temperature)
14890   ELSE
14895     INPUT "What is the PENETROMETER VOLUME (cc) ?",Penv
14900   END IF
14905   PRINT "Penetrometer Volume";Penv;"cc"
14910   REM
14915   REM ************************************
14920   REM Calculate the bulk density of sample
14925   REM ************************************
14930   REM
14935   Bulk_dens=PROUND(Swt/(Penv-(Eshgpore-Espore)/FNHg_density(Temperature)),-4)
14940   PRINT "Bulk density of sample";Bulk_dens;"g/cc"
14945   REM
14950   REM ******************************
14955   REM Input the penetrometer length
14960   REM ******************************
14965   REM
14970   INPUT "What is the PENETROMETER LENGTH (cm) ?",Penl
14975   PRINT "Penetrometer Length";Penl;"cm"
14980   REM
14985   REM ****************************************
14990   REM Input the number of low pressure
14995   REM intrusion points to be input (negative
15000   REM values not allowed)
15005   REM ****************************************
15010   REM
15015 Lp1:INPUT "How many low pressure points ?",Lp
15020   IF Lp<0 THEN
15025     PRINT "Negative numbers not allowed"
15030     GOTO Lp1
15035   END IF
15040   PRINT "Low pressure points =";Lp
15045   REM
15050   REM ************************************
15055   REM Input the number of the highest
15060   REM pressure point (cannot be less than
15065   REM the number of low pressure points)
15070   REM ************************************
15075   REM
15080 Hp1:INPUT "What is the highest pressure point # ?",Hp
15085   IF Hp<Lp THEN
15090     PRINT "Highest pressure point number cannot be less than number of low pressure poi
15095     GOTO Hp1
15100   END IF
15105   PRINT "Highest pressure point # =";Hp
15110   REM
```

```
15115    REM ****************************************
15120    REM Input the total number of points
15125    REM (cannot be less than the number of the
15130    REM highest pressure point)
15135    REM ****************************************
15140    REM
15145 D1:INPUT "What total number of pressure pointS ?",D
15150    IF D<Hp THEN
15155      PRINT "Total number of points cannot be less than the highest pressure point number"
15160      GOTO D1
15165    END IF
15170    REM
15175    REM ****************************************
15180    REM If the total number of points is zero
15185    REM then abort the program with a nasty
15190    REM message
15195    REM ****************************************
15200    REM
15205    IF NOT D THEN Abort_it
15210    PRINT "Total # of pressure point =";D
15215    Cy=1
15220    REM
15225    REM ****************************************
15230    REM If you want to correct any of the
15235    REM above input then answer yes
15240    REM NOTE: Data is not lost just press
15245    REM       CONTINUE for the current value
15250    REM       to be input
15255    REM ****************************************
15260    REM
15265    Yes_no("Any corrections ?",Yes)
15270    IF Yes THEN Start
15275    REM
15280    REM ****************************************
15285    REM Redimension the pressure and intrusion
15290    REM arrays
15295    REM ****************************************
15300    REM
15305    REDIM P(1:D),F(1:D)
15310    REM
15315    REM ****************************************
15320    REM If there are any low pressure data to
15325    REM be input then do so
15330    REM ****************************************
15335    REM
15340    IF Lp THEN
15345      PRINT USING "2/,K,/";"For the low pressure points"
15350      PRINT USING Ti1
15355      FOR I=1 TO Lp
15360        BEEP 1500,.01
15365        PRINT USING "#,2X,2D";I
15370        INPUT "What is the pressure ?",P(I)
15375        PRINT USING "#,12X,Z.3D,14X";P(I)
15380        INPUT "What is the intrusion ?",F(I)
15385        PRINT USING "2D.DD";F(I)
15390      NEXT I
15395 Ti1:IMAGE "NUMBER ",7X,"Pressure ",10X,"Intrusion "
15400      REM
15405      REM ****************************************
15410      REM If there are any corrections to be
15415      REM made to the low pressure data then
15420      REM answer yes
15425      REM ****************************************
15430      REM
15435      Yes_no("Any corrections ?",Yes)
15440      Flag1=0
15445      Flag2=0
15450 Cor:IF Yes THEN GOSUB Corrections
15455      IF Yes THEN CALL Yes_no("Any more corrections ?",Yes)
15460      IF Yes THEN Cor
15465    END IF
15470    REM
15475    REM ****************************************
15480    REM Input the high pressure intrusion data
15485    REM (if any)
15490    REM ****************************************
15495    REM
15500    PRINT USING "2/,K,K";"For cycle #";Cy
15505    IF Hp>Lp THEN
15510      PRINT USING "/,K,/";"For the high pressure intrusion points"
```

```
15515     PRINT USING Ti1
15520     FOR I=Lp+1 TO Hp
15525       BEEP 1500,.01
15530       PRINT USING "#,2X,2D";I
15535       INPUT "What is the pressure ?",P(I)
15540       PRINT USING "#,12X,3D.2D,13X";P(I)
15545       INPUT "What is the intrusion ?",F(I)
15550       PRINT USING "2D.DD";F(I)
15555     NEXT I
15560     REM
15565     REM ************************************
15570     REM If there are any corrections to be
15575     REM made to the high pressure intrusion
15580     REM data then answer yes
15585     REM ************************************
15590     REM
15595     Yes_no("Any corrections ?",Yes)
15600     Flag1=1
15605     Flag2=0
15610 Cor1:IF Yes THEN GOSUB Corrections
15615     IF Yes THEN CALL Yes_no("Any more corrections ?",Yes)
15620     IF Yes THEN Cor1
15625   END IF
15630   REM
15635   REM ************************************
15640   REM Calculate the mercury density and then
15645   REM the apparent density at the highest
15650   REM pressure
15655   REM ************************************
15660   REM
15665   Density=FNHg_density(Temperature)
15670   Apparent_d=PROUND(Swt/(Penv-Scf*(F(Lp+1)-F(Hp))-(Eshgpore-Espore)/Density),-4)
15675   PRINT USING C8;P(Hp),Apparent_d
15680 C8:IMAGE "The apparent density at ",3D.2D," MPa is ",Z.4D," g/cc"
15685   REM
15690   REM ************************************
15695   REM Input the high pressure extrusion data
15700   REM (if any)
15705   REM ************************************
15710   REM
15715   IF D>Hp THEN
15720     PRINT USING "2/,K,/";"For the high pressure extrusion points"
15725     PRINT USING Ti1
15730     FOR I=Hp+1 TO D
15735       BEEP 1500,.01
15740       PRINT USING "#,2X,2D";I
15745       INPUT "What is the pressure ?",P(I)
15750       PRINT USING "#,12X,3D.2D,13X";P(I)
15755       INPUT "What is the extrusion ?",F(I)
15760       PRINT USING "2D.DD";F(I)
15765     NEXT I
15770     REM
15775     REM ************************************
15780     REM If there are any corrections to be
15785     REM made to the high pressure extrusion
15790     REM data then answer yes
15795     REM ************************************
15800     REM
15805     Yes_no("Any corrections ?",Yes)
15810     Flag1=1
15815     Flag2=1
15820 Cor2:IF Yes THEN GOSUB Corrections
15825     IF Yes THEN CALL Yes_no("Any more corrections ?",Yes)
15830     IF Yes THEN Cor2
15835   END IF
15840   REM
15845   REM ************************************
15850   REM You get the option of storing the data
15855   REM input into a data file for future use
15860   REM ************************************
15865   REM
15870   Yes_no("Store the data ?",Yes)
15875   IF Yes THEN CALL Store_data
15880   REM
15885   REM ************************************
15890   REM Exit subprogram Mandata back to the
15895   REM calling program
15900   REM ************************************
15905   REM
15910   SUBEXIT
```

```
15915    REM
15920    REM ***************************************
15925    REM Subroutine Corrections
15930    REM
15935    REM To provide a means of correcting input
15940    REM intrusion data
15945    REM
15950    REM Input the number of the incorrect data
15955    REM data point
15960    REM ***************************************
15965    REM
15970 Corrections:INPUT "What is the incorrect range number ?",Check
15975    REM
15980    REM *********************************
15985    REM Low pressure intrusion data only
15990    REM *********************************
15995    REM
16000    IF NOT Flag1 AND NOT Flag2 AND (Check<1 OR Check>Lp) THEN Corrections
16005    REM
16010    REM *********************************
16015    REM High pressure intrusion data only
16020    REM *********************************
16025    REM
16030    IF Flag1 AND NOT Flag2 AND (Check<Lp+1 OR Check>Hp) THEN Corrections
16035    REM
16040    REM *********************************
16045    REM High pressure extrusion data only
16050    REM *********************************
16055    REM
16060    IF Flag1 AND Flag2 AND (Check<Hp+1 OR Check>D) THEN Corrections
16065    PRINT USING Cr3;Check
16070    REM
16075    REM ***************************************
16080    REM Print the data points input for that
16085    REM particular number and prompt the user
16090    REM to input the corrected values
16095    REM NOTE: If data is correct then just
16100    REM press CONTINUE to keep it
16105    REM ***************************************
16110    REM
16115    IF Flag1 AND Flag2 THEN
16120      REM
16125      REM *********************************
16130      REM High pressure extrusion data only
16135      REM *********************************
16140      REM
16145      PRINT USING Cra;P(Check),F(Check)
16150      INPUT "What is the new pressure reading ?",P(Check)
16155      PRINT USING Cr1a;P(Check)
16160      INPUT "What is the new extrusion reading ?",F(Check)
16165    ELSE
16170      REM
16175      REM ***************************************
16180      REM High and low pressure intrusion data
16185      REM ***************************************
16190      REM
16195      PRINT USING Cr;P(Check),F(Check)
16200      INPUT "What is the new pressure reading ?",P(Check)
16205      PRINT USING Cr1;P(Check)
16210      INPUT "What is the new intrusion reading ?",F(Check)
16215    END IF
16220    REM
16225    REM *********************************
16230    REM Print the corrected data points
16235    REM *********************************
16240    REM
16245    PRINT USING Cr2;F(Check)
16250    REM
16255    REM *********************************
16260    REM End of the subroutine Corrections
16265    REM *********************************
16270    REM
16275    RETURN
16280    REM
16285    REM ***************************************
16290    REM Format statements for printing data
16295    REM ***************************************
16300    REM
16305 Cr3:IMAGE /,"For the range number ",3D
16310 Cr:IMAGE "The old pressure is ",3D.DD," MPa.",/,"The old intrusion is ",2D.2D," pF."
```

```
16315 Cra:IMAGE "The old pressure is ",3D.DD," MPa.",/,"The old extrusion is ",2D.2D," pF."
16320 Cr1:IMAGE "The new pressure is ",3D.DD," MPa.",/,#,"The new intrusion is "
16325 Cr1a:IMAGE "The new pressure is ",3D.DD," MPa.",/,#,"The new extrusion is "
16330 Cr2:IMAGE 2D.DD," pF."
16335   REM
16340   REM ************************************
16345   REM If data input is truely garbage then
16350   REM print a nasty note and stop running
16355   REM ************************************
16360   REM
16365 Abort_it:PRINT USING Ass
16370   PRINT "You are giving me garbage as input."
16375   PRINT "Come back when you know what you are doing"
16380   PRINT USING Ass
16385   STOP
16390 Ass:IMAGE /,50("*"),/
16395   REM
16400   REM *************************
16405   REM End of subprogram Mandata
16410   REM *************************
16415   REM
16420 SUBEND
16425 SUB Plot_p_vs_a1(X(*),Y(*),Q(*),Cutoff,INTEGER High,Low,Total)
16430   REM
16435   REM ***************************************
16440   REM Subprogram Plot_p_vs_a1
16445   REM
16450   REM X(*)     The array containing the
16455   REM          corrected pressure values
16460   REM Y(*)     The array containing the pore
16465   REM          volume values
16470   REM Q(*)     The array containing the pore
16475   REM          area values
16480   REM Cutoff   The cutoff pressure for the
16485   REM          linear part of the curve
16490   REM High     The number of the highest
16495   REM          pressure point
16500   REM Low      The number of low pressure
16505   REM          points
16510   REM Total    The number of low and high
16515   REM          pressure points
16520   REM
16525   REM The common declarations are the same
16530   REM as in the main program
16535   REM
16540   REM          LOCAL VARIABLES
16545   REM
16550   REM INTEGER VARIABLES
16555   REM
16560   REM Yes      Either set to 1 (true) or set
16565   REM          to 0 (false)
16570   REM N        Number of points to be used in
16575   REM          the calculations
16580   REM Printer  The choice of printer (hard or
16585   REM          soft)
16590   REM I        Used as counter in the FOR..
16595   REM          NEXT loops
16600   REM P1x      Used to get hard clip limits
16605   REM P2x      coordinates from the plotter
16610   REM P1y      and output to plotter after
16615   REM P2y      the plot is finished
16620   REM Hplotter If set to 1 then hardcopy
16625   REM            plot
16630   REM          If set to 0 then softcopy plot
16635   REM Printer  Select code of the current
16640   REM          printer
16645   REM
16650   REM REAL VARIABLES
16655   REM
16660   REM X1       The sum of the pressure
16665   REM X2       The sum of the square of
16670   REM          pressure
16675   REM Y1       The sum of volume
16680   REM Y2       The sum of the square of
16685   REM          volume
16690   REM Z        The sum of pressure times
16695   REM          volume
16700   REM A        The intecept of the least
16705   REM          squares line
16710   REM B        The slope of the least squares
```

```
16715   REM             line
16720   REM Top         Intermediate value for Rsq
16725   REM Bottom      Intermediate value for Rsq
16730   REM Rsq         Correlation value (range 0-1)
16735   REM Area        The area at zero pressure
16740   REM Xmin        The minimum value of x-axis
16745   REM Xmax        The maximum value of x-axis
16750   REM Xtick       The distance between the tick
16755   REM             marks on the x-axis
16760   REM Ymin        The minimum value of y-axis
16765   REM Ymax        The maximum value of y-axis
16770   REM Ytick       The distance between the tick
16775   REM             marks on the y-axis
16780   REM Xscale      The space allowed for labels
16785   REM             on the x-axis
16790   REM Yscale      The space allowed for labels
16795   REM             on the y-axis
16800   REM
16805   REM DYNAMICALLY ALLOCATED ARRAYS
16810   REM
16815   REM T(*)        The array containing the
16820   REM             pressure values for the least
16825   REM             square calculations
16830   REM S(*)        THe array containing the pore
16835   REM             volumes for the least square
16840   REM             calculations
16845   REM ****************************************
16850   REM
16855   COM /Constants/ INTEGER Hcopy,Scopy,Splot,Hplot,Datalogger
16860   COM /Constants/ Splot$,Hplot$,Store$,Prog$,Security$
16865   INTEGER Yes,N,I,P1x,P2x,P1y,P2y
16870   INTEGER Hplotter,Printer
16875   REAL X1,X2,Y1,Y2,Z,A,B,Top,Bottom,Rsq,Area
16880   REAL Xmin,Xmax,Xtick,Ymin,Ymax,Ytick,Xscale,Yscale
16885   DIM Symbol$[1]
16890   ALLOCATE T(1:High-Low),S(1:High-Low)
16895   REM
16900   REM ************************************
16905   REM Zero the variables to be used for the
16910   REM least squares calculations and input
16915   REM the cutoff pressure
16920   REM ************************************
16925   REM
16930 Restart:Y1=0
16935   X1=0
16940   Z=0
16945   X2=0
16950   Y2=0
16955   N=0
16960   MAT T= (0)
16965   MAT S= (0)
16970   INPUT "What is the cutoff pressure ?",Cutoff
16975   REM
16980   REM ************************************
16985   REM Find the pressure and corresponding
16990   REM volume values that are greater than or
16995   REM equal to the input cutoff pressure
17000   REM ************************************
17005   REM
17010   FOR I=Low+1 TO High
17015     IF X(I)>=Cutoff THEN
17020       N=N+1
17025       T(N)=X(I)
17030       S(K)=Y(I)
17035     END IF
17040   NEXT I
17045   REM
17050   REM ************************************
17055   REM If less than two points are found then
17060   REM the operator will have to choose
17065   REM another cutoff pressure
17070   REM ************************************
17075   REM
17080   IF N<2 THEN Problem1
17085   REM
17090   REM ************************************
17095   REM Calculate the least squares values for
17100   REM the pressure and volume points
17105   REM ************************************
17110   REM
```

```
17115   FOR I=1 TO N
17120     X1=X1+T(I)
17125     Y1=Y1+S(I)
17130     Z=Z+T(I)*S(I)
17135     X2=X2+T(I)*T(I)
17140     Y2=Y2+S(I)*S(I)
17145   NEXT I
17150   REM
17155   REM ************************************
17160   REM Calculate the intercept and slope of
17165   REM the least squares line and the
17170   REM correlation constant
17175   REM ************************************
17180   REM
17185   B=(Z-X1*Y1/N)/(X2-X1*X1/N)
17190   A=Y1/N-B*X1/N
17195   Top=(Z-X1*Y1/N)^2
17200   Bottom=(X2-X1*X1/N)*(Y2-Y1*Y1/N)
17205   Rsq=Top/Bottom
17210   REM
17215   REM ************************************
17220   REM Set printer to softcopy and see if the
17225   REM intercept lies between the first and
17230   REM last pore volume values and if it does
17235   REM then go and calculate the area
17240   REM ************************************
17245   REM
17250   Printer=Scopy
17255 Replay:PRINTER IS Printer
17260   FOR I=1 TO Total-1
17265     IF (Y(I)<=A) AND (Y(I+1)>=A) THEN Found_it
17270   NEXT I
17275   REM
17280   REM ************************************
17285   REM If the intercept does not lie between
17290   REM valid points then see if the operator
17295   REM wants to try again
17300   REM ************************************
17305   REM
17310 Problems:PRINT "No area possible due to lousy data"
17315   BEEP 3000,.02
17320   GOTO Try_two
17325   REM
17330   REM ************************************
17335   REM Tells the operator the cutoff pressure
17340   REM is too high and the computer will ask
17345   REM if the operator wants to try again
17350   REM ************************************
17355   REM
17360 Problem1:PRINT "Need at least two points to make a line.  The cutoff pressure is too hi
17365   BEEP 3000,.02
17370   GOTO Try_two
17375   REM
17380   REM ************************************
17385   REM The intercept is valid and the area is
17390   REM calculated as a linear interpolation
17395   REM between the bounding points
17400   REM ************************************
17405   REM
17410 Found_it:Area=Q(I)+(Q(I+1)-Q(I))/(Y(I+1)-Y(I))*(A-Y(I))
17415 Eq:IMAGE "Equation for the line is:  Volume = ",Z.4D," + ",Z.3DE," * Pressure"
17420 Eq1:IMAGE "Equation for the line is:",/,"Volume = ",Z.4D," + ",Z.3DE," * Pressure"
17425   REM
17430   REM ************************************
17435   REM The least squares equation is printed
17440   REM and also the correlation constant, the
17445   REM number of points used, the cutoff
17450   REM pressure and the corrected area
17455   REM ************************************
17460   REM
17465   IF Printer=Hcopy THEN PRINT USING Eq;A,B
17470   IF Printer=Scopy THEN PRINT USING Eq1;A,B
17475   PRINT USING "K,Z.3D";"The correlation is ",Rsq
17480   PRINT USING "K,K";"Number of points used were ";N
17485   PRINT USING "K,3D.D,K,/";"The cut off pressure was ",Cutoff," MPa"
17490   PRINT USING "K,D.3DE,K,3/";"Corrected area is ";Area;" m^2/g"
17495   IF Printer=Scopy THEN
17500     REM
17505     REM ************************************
17510     REM If the printer is the softcopy then
```

```
17515     REM the operator has the option of a hard
17520     REM copy of the display otherwise the
17525     REM printer is set to the softcopy
17530     REM ***************************************
17535     REM
17540     Yes_no("Do you want a hard copy ?",Yes)
17545     IF Yes THEN
17550       Printer=Hcopy
17555       GOTO Replay
17560     END IF
17565   ELSE
17570     Printer=Scopy
17575   END IF
17580   REM
17585   REM ***************************************
17590   REM The operator has the oportunity to try
17595   REM another cutoff pressure
17600   REM ***************************************
17605   REM
17610 Try_two:Yes_no("Do you want to try another cutoff pressure ?",Yes)
17615   IF Yes THEN Restart
17620   REM
17625   REM ***************************************
17630   REM The graph is plotted on the softcopy
17635   REM plotter first and then a hardcopy
17640   REM option is offered
17645   REM ***************************************
17650   REM
17655 Plotting:PRINTER IS Scopy
17660   REM
17665   REM ***************************************
17670   REM Intialize plotter, clear the screen
17675   REM turn on the graphics display and setup
17680   REM the plotter to display the curve
17685   REM ***************************************
17690   REM
17695   GINIT
17700   PLOTTER IS Splot,Splot$
17705   OUTPUT 2 USING "#,B";255,75  !CLEAR SCREEN
17710   GCLEAR
17715   GRAPHICS ON
17720   ALPHA OFF
17725   REM
17730   REM ***************************************
17735   REM Set up the maximums, minimums and the
17740   REM distances between the tick marks for
17745   REM the scaling and the drawint of the
17750   REM axes
17755   REM ***************************************
17760   REM
17765   Xmin=0
17770   Xtick=20
17775   Xmax=200
17780   Ymin=0
17785   REM
17790   REM ***************************************
17795   REM Using the maximum volume value set up
17800   REM the maximum for the scaling of the
17805   REM Y-axis
17810   REM ***************************************
17815   REM
17820   Ymax=PROUND((S(N)),-1)+.1
17825   Ytick=Ymax/10
17830   REM
17835   REM ***************************************
17840   REM Set the plotter up for:
17845   REM
17850   REM 1. The labels centred
17855   REM 2. The line is smooth and continuous
17860   REM 3. The functions use degree mode
17865   REM 4. The character size is set
17870   REM 5. Pen number one is selected
17875   REM 6. The label direction is horizontal
17880   REM    (0 degrees)
17885   REM ***************************************
17890   REM
17895 Hprpt:LORG 5
17900   LINE TYPE 1
17905   DEG
17910   CSIZE 3,.6
```

```
17915   PEN 1
17920   LDIR 0
17925   REM
17930   REM ************************************
17935   REM If the plotter is the softcopy then
17940   REM set the hardclip limits to be above
17945   REM the key label area
17950   REM ************************************
17955   REM
17960   IF NOT Hplotter THEN VIEWPORT 10,130,10,100
17965   REM
17970   REM ****************************************
17975   REM Scale plotting area and draw the axes
17980   REM ****************************************
17985   REM
17990   WINDOW -Xtick,Xmax+Xtick,-Ytick,Ymax+Ytick
17995   CLIP Xmin,Xmax,Ymin,Ymax
18000   AXES Xtick,Ytick,0,0,1,2
18005   CLIP OFF
18010   REM
18015   REM **********
18020   REM Label axes
18025   REM **********
18030   REM
18035   FOR I=0 TO 200 STEP Xtick
18040     MOVE I,-Ytick/4
18045     LABEL USING "K";I
18050   NEXT I
18055   REM
18060   REM **********************************
18065   REM NOTE: Label every other tick mark
18070   REM **********************************
18075   REM
18080   FOR I=0 TO Ymax STEP Ytick*2
18085     MOVE -10,I
18090     LABEL USING "Z.DD";I
18095   NEXT I
18100   REM
18105   REM ************************
18110   REM Label what the x-axis is
18115   REM ************************
18120   REM
18125   MOVE 100,-Ytick*.75
18130   LABEL USING "K";"Pressure (MPa)"
18135   REM
18140   REM **********************************
18145   REM Rotate label direction 90 degrees
18150   REM Label what the y axis is
18155   REM Return label direction back to
18160   REM horizontal (0 degrees)
18165   REM **********************************
18170   REM
18175   LDIR 90
18180   MOVE -28,Ymax/2
18185   LABEL USING "K";"Volume (cc/g)"
18190   LDIR 0
18195   REM
18200   REM ****************************************
18205   REM Plot the pressure vs volume points
18210   REM
18215   REM Use different symbols to differentiate
18220   REM the low and high pressure points
18225   REM ****************************************
18230   REM
18235   FOR I=1 TO Total
18240     IF I<=Low THEN Symbol$="#"
18245     IF (I>Low) AND (I<=High) THEN Symbol$="*"
18250     IF I>High THEN Symbol$="+"
18255     MOVE X(I),Y(I)
18260     LABEL USING "K";Symbol$
18265   NEXT I
18270   REM
18275   REM ****************************************
18280   REM Using a dashed line draw the least
18285   REM squares line from 0 to 200 Mpa
18290   REM
18295   REM Reset the line type to smooth and lift
18300   REM up the pen
18305   REM ****************************************
18310   REM
```

```
18315    LINE TYPE 5
18320    MOVE 0,A
18325    DRAW 200,A+B*200
18330    LINE TYPE 1
18335    PENUP
18340    REM
18345    REM ************************************
18350    REM If the hardcopy plotter is used then
18355    REM clean it up for the next user
18360    REM ************************************
18365    REM
18370    IF Hplotter THEN Pxxx
18375    REM
18380    REM ************************************
18385    REM Wait until the operator wished to move
18390    REM on
18395    REM ************************************
18400    REM
18405    Pauser
18410    REM
18415    REM ************************************
18420    REM The operator has the option of getting
18425    REM a hardcopy of the graph
18430    REM ************************************
18435    REM
18440    Yes_no("Do you want a hard copy ?",Yes)
18445    IF NOT Yes THEN SUBEXIT
18450 Hplt:Yes_no("Do you want to use the plotter ?",Yes)
18455    REM
18460    REM ************************************
18465    REM If the operator wants a plotter copy
18470    REM of the curve then answer yes and then
18475    REM set up the plotter for plotting curve
18480    REM ************************************
18485    REM
18490    IF Yes THEN
18495      REM
18500      REM ************************************
18505      REM Load the paper and set the hardclip
18510      REM limits of the plotter
18515      REM NOTE: The x-axis and y-axis are
18520      REM       divided into 10 blocks
18525      REM ************************************
18530      REM
18535 Set1:Yes_no("Is the paper loaded & P1 and P2 set ?",Yes)
18540      IF NOT Yes THEN Set1
18545      REM
18550      REM ************************************
18555      REM Set the printer to the plotter
18560      REM address and request the current hard
18565      REM clip limits.  Then calculate the new
18570      REM hardclip limits (allow for labels)
18575      REM and output to the plotter
18580      REM Identify the plotter to the graphics
18585      REM and change the pen speed ot 5 cm/s
18590      REM for a smoother plot
18595      REM Set the labels to be centred
18600      REM Enable the SFK to interupt and allow
18605      REM a smooth exit from the plotting mode
18610      REM Go and plot the curve
18615      REM ************************************
18620      REM
18625      PRINTER IS Hplot
18630      PRINT "OP;"
18635      ENTER Hplot;P1x,P1y,P2x,P2y
18640      Xscale=(P2x-P1x)*Xtick/Xmax
18645      Yscale=(P2y-P1y)*Ytick/Ymax
18650      PRINT USING Chng;"IP",P1x-Xscale,",",P1y-Yscale,",",P2x+Xscale,",",P2y+Yscale,";"
18655      PLOTTER IS Hplot,Hplot$
18660      PRINT "VS5;"
18665      LORG 5
18670      Hplotter=1
18675      ON KEY 4 LABEL "ABORT" GOTO Pxxx
18680      GOTO Hprpt
18685    END IF
18690    REM
18695    REM ************************************
18700    REM You are given the option of a copy of
18705    REM the softcopy graphics on the printer
18710    REM ************************************
```

```
18715   REM
18720   Yes_no("Do you want a thermal copy ?",Yes)
18725   IF Yes THEN
18730     REM
18735     REM ***************************************
18740     REM Print the title of the graph
18745     REM Dump the graph to the printer
18750     REM output a linefeed for easeir viewing
18755     REM ***************************************
18760     REM
18765     OUTPUT Hcopy USING "K";"Pressure (MPa) vs Pore Volume (cc/g)"
18770     DUMP GRAPHICS
18775     OUTPUT Hcopy USING "/"
18780   END IF
18785   REM
18790   REM ***************************************
18795   REM Exit the subprogram Plot_p_vs_a1 back
18800   REM to the calling program
18805   REM ***************************************
18810   REM
18815   SUBEXIT
18820   REM
18825   REM ***************************************
18830   REM Cleanup the plotter for the next user
18835   REM by:
18840   REM
18845   REM 1. Lifting up the pen
18850   REM 2. Turning off the SFK interupts
18855   REM 3. Returning the pen to the stall
18860   REM 4. Initializing the plotter
18865   REM 5. Output to plotter the original hard
18870   REM    clip limits
18875   REM 6. Set the printer to be the softcopy
18880   REM 7. Set the plotter to be the softcopy
18885   REM 8. Return to prompt for a hardcopy
18890   REM ***************************************
18895   REM
18900 Pxxx:PENUP
18905   OFF KEY
18910   PEN 0
18915   PRINT "IN;"
18920   PRINT USING Chng;"IP",P1x,",",P1y,",",P2x,",",P2y,";"
18925   PRINTER IS Scopy
18930   PLOTTER IS Splot,Splot$
18935   Hplotter=0
18940 Chng:IMAGE 2A,4(5D,A)
18945   GOTO Hplt
18950   REM
18955   REM *********************************
18960   REM End of subprogram Plot_p_vs_a1
18965   REM *********************************
18970   REM
18975 SUBEND
18980 DEF FNIntrusion
18985   REM
18990   REM ***************************************
18995   REM Function Intrusion
19000   REM
19005   REM Collect the voltage readings for the
19010   REM high pressure intrusion and convert to
19015   REM engineering units (pF) and return to
19020   REM calling program
19025   REM
19030   REM Common declarations are the same as in
19035   REM the main program
19040   REM
19045   REM           Local variables
19050   REM
19055   REM Real variables
19060   REM
19065   REM Intrus is the voltage of the high
19070   REM        pressure intrusion monitor in
19075   REM        poresimeter
19080   REM
19085   REM Datalogger commands
19090   REM
19095   REM AI -input voltage on the relay defined
19100   REM     by variable Intrusion
19105   REM ***************************************
19110   REM
```

```
19115   COM /Poresimeter/ INTEGER Slot,Up,Down,Pressure,Intrusion,@Poresimeter
19120   REAL Intrus
19125   OUTPUT @Poresimeter USING "2A,3D";"AI",Intrusion
19130   ENTER @Poresimeter;Intrus
19135   RETURN PROUND(-20.2562710975+196.599718754*Intrus,-2)
19140   REM
19145   REM ************************************
19150   REM Return the intrusion reading (pF) to
19155   REM calling program
19160   REM
19165   REM End of function Intrusion
19170   REM ************************************
19175   REM
19180 FNEND
19185 DEF FNPressure
19190   REM
19195   REM ****************************************
19200   REM Function Pressure
19205   REM
19210   REM Collect the voltage readings for the
19215   REM high pressure and convert to
19220   REM engineering units (MPa) and return to
19225   REM calling program
19230   REM
19235   REM Common declarations are the same as in
19240   REM the main program
19245   REM
19250   REM          Local variables
19255   REM
19260   REM Real variables
19265   REM
19270   REM Press  is the voltage of the high
19275   REM        pressure transducer of the
19280   REM        poresimeter
19285   REM
19290   REM Datalogger commands
19295   REM
19300   REM AI -input voltage on the relay defined
19305   REM     by variable Pressure
19310   REM ****************************************
19315   REM
19320   COM /Poresimeter/ INTEGER Slot,Up,Down,Pressure,Intrusion,@Poresimeter
19325   REAL Press
19330   OUTPUT @Poresimeter USING "2A,3D";"AI",Pressure
19335   ENTER @Poresimeter;Press
19340   RETURN PROUND(-.1005268172+40.644124429*Press,-2)
19345   REM
19350   REM ************************************
19355   REM Return the high pressure reading (MPa)
19360   REM to the calling program
19365   REM
19370   REM End of function Pressure
19375   REM ************************************
19380   REM
19385 FNEND
19390 DEF FNHg_density(Temperature)
19395   REM
19400   REM ************************************
19405   REM Function Hg_density
19410   REM
19415   REM Returns the density of mercury when
19420   REM given the temperature (°C)
19425   REM
19430   REM Temperature  The temperature in
19435   REM                degrees celcius
19440   REM ************************************
19445   REM
19450   RETURN PROUND(13.59526-.00245*Temperature,-4)
19455   REM
19460   REM ***************************
19465   REM End of function Hg_density
19470   REM ***************************
19475   REM
19480 FNEND
19485 SUB Abort
19490   REM
19495   REM ****************************************
19500   REM Subprogram Abort
19505   REM
19510   REM Turns off the poresimeter up and down
```

```
19515   REM switch and resets the datalogger
19520   REM
19525   REM common declarations are the same as in
19530   REM the main program
19535   REM
19540   REM Datalogger commands
19545   REM
19550   REM TD - Display the time and date
19555   REM ***************************************
19560   REM
19565   COM /Poresimeter/ INTEGER Slot,Up,Down,Pressure,Intrusion,@Poresimeter
19570   COM /Read/ Mpa,Pf,Timeit,Reader
19575   REM
19580   REM ******************************
19585   REM Switch off poresimeter switch
19590   REM ******************************
19595   REM
19600   Switch(3)
19605   REM
19610   REM ***************************************
19615   REM Reset the datalogger to default values
19620   REM Have it display the time and revert to
19625   REM local control
19630   REM ***************************************
19635   REM
19640   CLEAR @Poresimeter
19645   OUTPUT @Poresimeter;"TD"
19650   LOCAL @Poresimeter
19655   REM
19660   REM ************************
19665   REM End of subprogram Abort
19670   REM ************************
19675   REM
19680 SUBEND
19685 SUB Store_data
19690   REM
19695   REM ***************************************
19700   REM Subprogram Store_data
19705   REM
19710   REM Store the manually input data in the
19715   REM correct datafile
19720   REM
19725   REM The common declarations are the same
19730   REM as in the main program
19735   REM
19740   REM         Local variables
19745   REM
19750   REM Character strings
19755   REM
19760   REM File$[10]  Name of data file
19765   REM
19770   REM Integer variables
19775   REM
19780   REM Np          Number of high pressure
19785   REM             data points
19790   REM First       The size of the first
19795   REM             record in the data file
19800   REM Filesize    The size of the subsequent
19805   REM             records in the data file
19810   REM Yes         Returned as 1 (true) or as
19815   REM             0 (false)
19820   REM I           Counter in FOR..NEXT loops
19825   REM Outcome     Return variable in ASSIGN
19830   REM             statement
19835   REM
19840   REM Dynamically Allocated
19845   REM
19850   REM P1(*)       The array for high pressure
19855   REM F1(*)       The array for high pressure
19860   REM             intrusion
19865   REM ***************************************
19870   REM
19875   COM /Constants/ INTEGER Hcopy,Scopy,Splot,Hplot,Datalogger
19880   COM /Constants/ Splot$,Hplot$,Store$,Prog$,Security$
19885   COM /Analyse/ Temperature,Penl,Pend,Penv,Hgst,Cona,Scf
19890   COM /Analyse/ INTEGER D,Hp,Lp,Cy
19895   COM /Analyse/ Date$,Title$,Swt,Pen_id$,P(*),F(*)
19900   COM /Analyse/ Epore,Espore,Eshgpore
19905   ALLOCATE P1(1:D-Lp),F1(1:D-Lp)
19910   INTEGER Np,First,Filesize,Yes,I,Outcome
```

```
19915   DIM File$[10]
19920   REM
19925   REM ****************************************
19930   REM Figure out the number of high pressure
19935   REM set points and calculate the size of
19940   REM the data file (choose the largest of
19945   REM the two (First or Filesize)) in 256
19950   REM record blocks (minimum 1 block)
19955   REM
19960   REM First=The number of low pressure data
19965   REM       pairs + the other data (integer
19970   REM       blocks of 256 bytes)
19975   REM
19980   REM Filesize=The number of high pressure
19985   REM          points + overhead (integer
19990   REM          blocks of 256 bytes)
19995   REM ****************************************
20000   REM
20005   Hp=(D-Lp)
20010   First=((Lp*8*2+200) DIV 255)+1
20015   Filesize=((Hp*8+20) DIV 255)+1
20020   IF Filesize<=First THEN Filesize=First
20025   REM
20030   REM ************************************
20035   REM Output to the operator the current
20040   REM file name to modify and then input to
20045   REM the computer.
20050   REM ************************************
20055   REM
20060 Fi:OUTPUT 2;File$;
20065   LINPUT "What is the file name ?",File$
20070   REM
20075   REM ****************************************
20080   REM You may now insert the appropriate
20085   REM data media in the storage device
20090   REM specfied by Store$
20095   REM
20100   REM If there are any problems then the
20105   REM following cases will hopefully cope
20110   REM with them.  They are identified by the
20115   REM return variable Outcome on the assign
20120   REM statement
20125   REM
20130   REM CASE 0
20135   REM
20140   REM If the file exists and is the correct
20145   REM type (BDAT) then the computer will ask
20150   REM if it may overwrite the the data that
20155   REM already exists in the file.
20160   REM NOTE: This will purge the file and
20165   REM       then create it again !!!!!!!
20170   REM
20175   REM CASE 56
20180   REM
20185   REM If the file doesn't exist then it will
20190   REM create the correctly sized BDAT file
20195   REM (BDAT = binary format data )
20200   REM
20205   REM CASE 58
20210   REM
20215   REM If the file exists and is a program
20220   REM type file or an ASCII type file then
20225   REM you must choose another name
20230   REM
20235   REM CASE 53
20240   REM
20245   REM If the filename is too long (more than
20250   REM 10 characters then you will have to
20255   REM input another file name
20260   REM
20265   REM CASE 80
20270   REM
20275   REM If the media isn't installed correctly
20280   REM or if the door is open then correct
20285   REM the problem. Then you will have to
20290   REM input the file name again.
20295   REM
20300   REM CASE 62
20305   REM
20310   REM If the data file exists but is not one
```

```
20315   REM created by this program then you will
20320   REM have to input another file name
20325   REM This is done by the security code and
20330   REM is the way the program distinguishes
20335   REM between ASCII and BDAT data files
20340   REM
20345   REM CASE ELSE
20350   REM
20355   REM If there is a fatal error then the
20360   REM the program will stop and you will
20365   REM have to restart the process again.
20370   REM ****************************************
20375   REM
20380   Yes_no("Is the correct data disc installed ?",Yes)
20385   ASSIGN @File TO File$&Security$&Store$;RETURN Outcome
20390   SELECT Outcome
20395   CASE 0
20400     Yes_no("File in existance OVERWRITE DATA ?",Yes)
20405     IF NOT Yes THEN Start
20410   CASE 58
20415     PRINT File$&Store$&" is not a data file"
20420     GOTO Fi
20425   CASE 53
20430     PRINT File$&" is too long a name (MAX 10 characters)"
20435     GOTO Start
20440   CASE 56
20445     CREATE BDAT File$&Security$&Store$,1+Cy,Filesize*256
20450     ASSIGN @File TO File$&Security$&Store$
20455   CASE 62
20460     PRINT File$&Store$&" was not created by this program"
20465     GOTO Start
20470   CASE 80
20475     PRINT "The door is open or media is not installed"
20480     GOTO Fi
20485   CASE ELSE
20490     PRINT "FATAL ERROR"
20495     PRINT Outcome;" is the error number"
20500     STOP
20505   END SELECT
20510   REM
20515   REM ***********************************
20520   REM Output the data into the data file
20525   REM ***********************************
20530   REM
20535   REM ***********************************
20540   REM Output to the first record block
20545   REM ***********************************
20550   REM
20555   OUTPUT @File,1;Title$,Date$,Pen_id$,Lp,D,Hp,Temperature
20560   IF Lp THEN
20565     REDIM P(1:Lp),F(1:Lp)
20570     OUTPUT @File;P(*),F(*)
20575     REDIM P(1:D),F(1:D)
20580   END IF
20585   OUTPUT @File;Cy,Penl,Pend,Penv,Hgst,Cona,Scf,Epore,Espore,Eshgpore
20590   REM
20595   REM ****************************************
20600   REM Build array of high pressure data for
20605   REM output to the data file
20610   REM ****************************************
20615   REM
20620   FOR I=Lp+1 TO D
20625     P1(I-Lp)=P(I)
20630     F1(I-Lp)=F(I)
20635   NEXT I
20640   REM
20645   REM ***********************************
20650   REM Output to the second record block
20655   REM ***********************************
20660   REM
20665   OUTPUT @File,1+Cy;P1(*),F1(*)
20670   REM
20675   REM ********************
20680   REM Close the data file
20685   REM ********************
20690   REM
20695   ASSIGN @File TO *
20700   REM
20705   REM ********************************
20710   REM End of the subprogram Store_data
```

```
20715    REM ************************************
20720    REM
20725 SUBEND
```

APPENDIX B: Theory behind the mercury porosimeter data analysis.

The diameter of a cylindrical pore is given by the equation

$$\text{Diameter } (\mu m) = -0.004\ \gamma\ P \cos\theta \qquad (1)$$

where

γ is surface tension of liquid (dynes cm^{-1})

θ is contact angle (degrees)

P is pressure (MPa 10^6 Nm^{-2})

During the high pressure determinations, the penetrometer is in a vertical position and the pressure or head of the mercury column needs to be taken into account. This is a dynamic factor because the column of mercury decreases with increasing pressure. The initial height and diameter the column of mercury is known. The head P_0 (MPa) is given by:

$$P_0 = 10^{-5} \rho\ h_0 g \qquad (2)$$

where

ρ is density of mercury (g cm^{-3}) which is a function of temperature.

h_0 is stem length (cm)

g is acceleration of gravity (m s^{-2})

The initial volume V_0 (cm^3) is easily calculated by using the equation for the volume of a cylinder.

$$V_0 = \frac{\pi}{4} d^2\ h_0 \qquad (3)$$

where

d is diameter of penetrometer (cm)

h_0 is the length of the penetrometer stem (cm)

The corrected pressure (P_C) is related to the ratio of the initial height and the changed height of the column of mercury:

$$P_C = P_0 \, h/h_0 \tag{4}$$

where

P_0 is initial pressure (MPa)

h is new length of mercury column (cm)

h_0 is length of stem (cm)

The volume of the change in column of mercury is given (cm^3)

$$V = \frac{\pi}{4} d^2 \, (h_0 - h) \tag{5}$$

where

d is the diameter of mercury column (cm)

h_0 is the stem length (cm)

h is the length of the mercury column (cm)

Equating (5) and (3) and substituting (4) gives

$$P_C = P_0 - \frac{P_0}{V_0} V \tag{6}$$

Using (2) yields

$$P_C = 10^{-5} \, \rho \, h_0 g \, \frac{(1-4V)}{\pi d^2 h_0} \tag{7}$$

V is also calculated by measuring the changes in capacitance in the penetrometer with increasing pressure:

$$V = (F_0 - F) * \text{stem correction factor} \qquad (8)$$

where

F_0 is initial capacitance (pF)

F is observed capacitance (pF)

Stem correction factor ($cm^3\ pF^{-1}$)

Thus (7) becomes:

$$P_C = 10^{-5}\ \rho h_0 g\ \left(1 - \frac{4(F_0 - F) * SCF}{\pi\ d^2 h_0}\right) \qquad (9)$$

where

ρ is density of mercury ($g\ cm^{-3}$) as a function of temperature

g is the acceleration due to gravity ($m\ s^{-2}$)

d is the diameter of the column of liquid in the penetrometer (cm)

h_0 is the height of the penetrometer stem (cm)

SCF is the conversion factor of the penetrometer ($cm^3\ pF^{-1}$)

F_0 is the initial capacitance at atmospheric pressure (pF)

F is the observed capacitance reading (pF)

The pressure (P) is a function of two components

$$P = P_{obs} + P_C \qquad (10)$$

where

P_{obs} is the observed pressure (MPa)

P_C is correction factor (MPa)

From (1) and (10) the diameter is given as

$$\text{Diameter } (\mu m) = \frac{-0.004\gamma \cos\theta}{P_{obs} + 10^{-5} \rho h_0 g \left(1 - \frac{4(F_0 - F) * SCF}{\pi d^2 h_0}\right)} \quad (11)$$

where

γ is surface tension (dynes/cm)

θ is contact angle (degrees)

ρ is density of mercury (g cm^{-3}) as a function of temperature

g is the acceleration due to gravity (m s^{-2})

d is the diameter of the column of liquid in the penetrometer (cm)

h_0 is the height of the penetrometer stem (cm)

SCF is the conversion factor of the penetrometer (cm^3 pF^{-1})

F_0 is the initial capacitance at atmospheric pressure (pF)

F is the observed capacitance reading (pF)

P_{obs} is the observed pressure reading (MPa)

Pore area: The cumulative pore area (not assuming any particular pore geometry) is determined by integrating the cumulative pore volume curve. PdV or work (dW) done on the system when mercury is intruded into the pores is determined and related to pore area.

Thus

$$\gamma \cos \theta \, dA = PdV = dW$$

$$dA = \frac{-PdV}{\gamma \cos \theta} \tag{12}$$

$$A = \frac{-1}{\gamma \cos \theta} \int_{Vmin}^{Vmax} PdV \tag{13}$$

where

dV is the volume change (cm^3)
P is the pressure (MPa)
γ is the surface tension of the mercury (dynes cm^{-1})
θ is the contact angle (degrees)

To get A in m^2/g

$$A = \frac{-10^3}{m\gamma \cos \theta} \sum_1^J P\Delta V \tag{14}$$

where

m is the mass of sample (grams)
γ is surface tension (dynes cm^{-1})
θ is the contact angle (degrees)
P is observed pressure for a particular reading (MPa)
ΔV is the change in the volume for a particular reading (cm^3)

Note: m can be disregarded if ΔV has been calculated using volumes that have been normalized to cm^3/g.